Geol Survey

Guide to the Geology of the Joliet Area, Cook, Grundy, and Will Counties

David L. Reinertsen
Lisa R. Smith

Geological Science Field Trip 1990B, May 12, 1990
Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
Champaign, Illinois 61820

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Geological Science Field Trips The Educational Extension Unit of the Illinois State Geological Survey conducts four free tours during the year to acquaint the public with the state's landscape, rock and mineral resources, and the geological processes that have led to their origin. With this program, we hope to stimulate a general interest in the geology of Illinois and a greater appreciation of the state's vast mineral resources and their importance to the overall economy.

Each field trip is an all-day excursion through one or more Illinois counties; frequent stops are made to explore, explain, discuss, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers in preparing earth science units. Grade school students are welcome but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students. A list of earlier field trip guide leaflets for planning class tours and private outings may be obtained by contacting the Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. (217) 244-2407 or 333-7372.

Please Note Several of the stops in the itinerary for this field trip are located on private property. The owners have graciously given us permission to visit their lands. Please obey all instructions from the trip leaders and conduct yourselves in a manner that respects the property owners' cooperation. So that we may be welcome to return on future field trips, please do not litter; don't climb on fences; leave all gates as you found them. These simple rules of courtesy also apply to public property. Because of trespass laws and liability constraints, you *must* get permission from property owners, or their agents, before entering private property.

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GEOLOGIC FRAMEWORK OF THE JOLIET AREA

The area of the Joliet geological science field trip is within the Illinois and Michigan Canal National Heritage Corridor in Cook, Grundy, and Will Counties, an area of special importance in the economic development of Illinois during the 1800s. The major objective of this field trip is to acquaint you with the geology, landscape, and mineral resources of the area. This guide draws heavily on the report prepared for the National Park Service by Lisa R. Smith and others (1986).

Bedrock The Joliet area has undergone many changes through hundreds of millions of years of geologic time. The oldest rocks beneath us on the field trip route are the ancient Precambrian "basement complex." We know relatively little about these rocks from direct observations because they are not exposed at the Earth's surface anywhere in Illinois. A few drill holes in Illinois have reached deep enough to collect samples from these rocks. From these samples, we know that the rocks formed about 1.0 to 1.5 billion years ago and that they consist mostly of igneous and metamorphic rocks of granitic composition.

Indirect evidence about the nature of the basement complex comes from the branch of geology known as geophysics. Geophysicists and geologists map variations in the rocks of the basement complex by studying data on the passage of earthquake waves through the Earth's crust, seismic reflection and refraction profiles taken by oil companies and others, and measurements of the gravitational and magnetic fields of the Earth.

Almost 4,500 feet of sedimentary rocks deposited during the Paleozoic Era and glacial deposits of the Cenozoic Era now cover the basement rocks in the field trip area. Shells of marine animals and plants, muds, silts, and sands, deposited in the shallow seas and estuaries that repeatedly inundated interior regions of our continent, lithified into solid rocks of limestone and dolomite, shale, siltstone, and sandstone through time (Willman, 1973; Buschbach, 1971). The geologic column for this area (fig. 1) shows the vertical succession of rock strata beginning with the oldest formations at the bottom. These rocks began to form about 525 million years ago from sediments deposited during the Cambrian Period. They continued to form as more sediments were deposited during the Ordovician, Silurian, Devonian, Pennsylvanian, and Permian Periods of the Paleozoic Era (fig. 1). The Pennsylvanian strata, which are less than 300 million years old, form the youngest remaining bedrock in the area. Rocks of the Devonian and Permian Periods probably were deposited in the region but were subsequently eroded away, so there are some large gaps in the rock record. Farther south in Illinois at least 15,000 feet of Paleozoic sedimentary strata accumulated (fig. 2). The Paleozoic Era lasted from about 570 million years ago until the end of the Permian Period some 245 million years ago.

A geological formation is a set of rocks that is distinctive enough in character to be readily recognizable in the field and thick enough to be plotted on a geologic map. Here in northern Illinois there are sequences of several formations that are quite similar in composition and appearance. Because they are so similar, these sequences of formations are generally classified and mapped together in a unit called a group (see fig. 1). As noted by Willman (1971), many of the formations within these groups in the Chicago area have conformable contacts; that is, no significant interruptions in deposition took place between formations (fig. 1). In some instances, even though the composition and appearance of the rocks change significantly at the contact between two formations, the fossils in the rocks and the relationships between the rocks at the contact indicate that deposition was essentially continuous. At other contacts, however, the lower formation has been subjected to

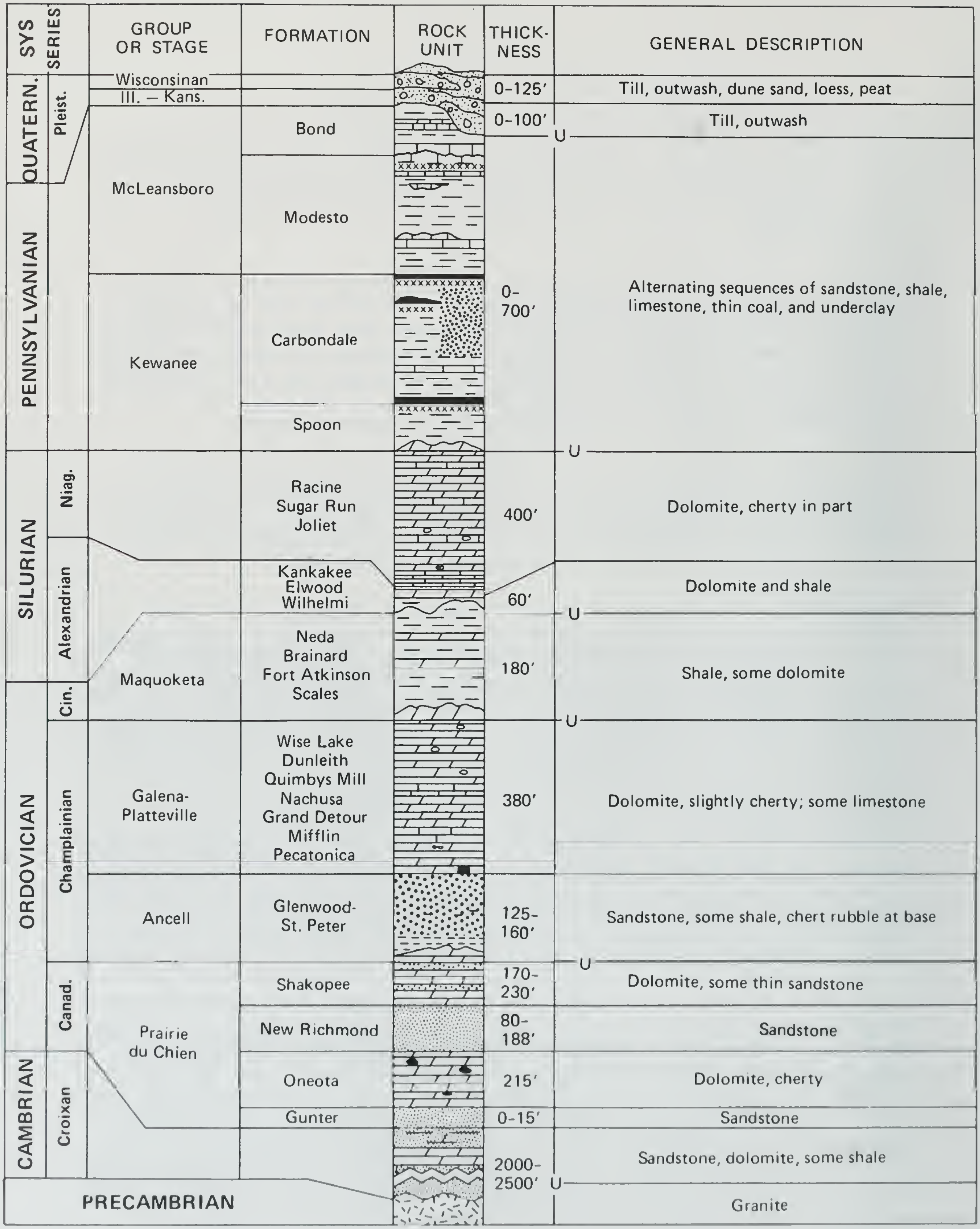


Figure 1 Geologic column of the study area.

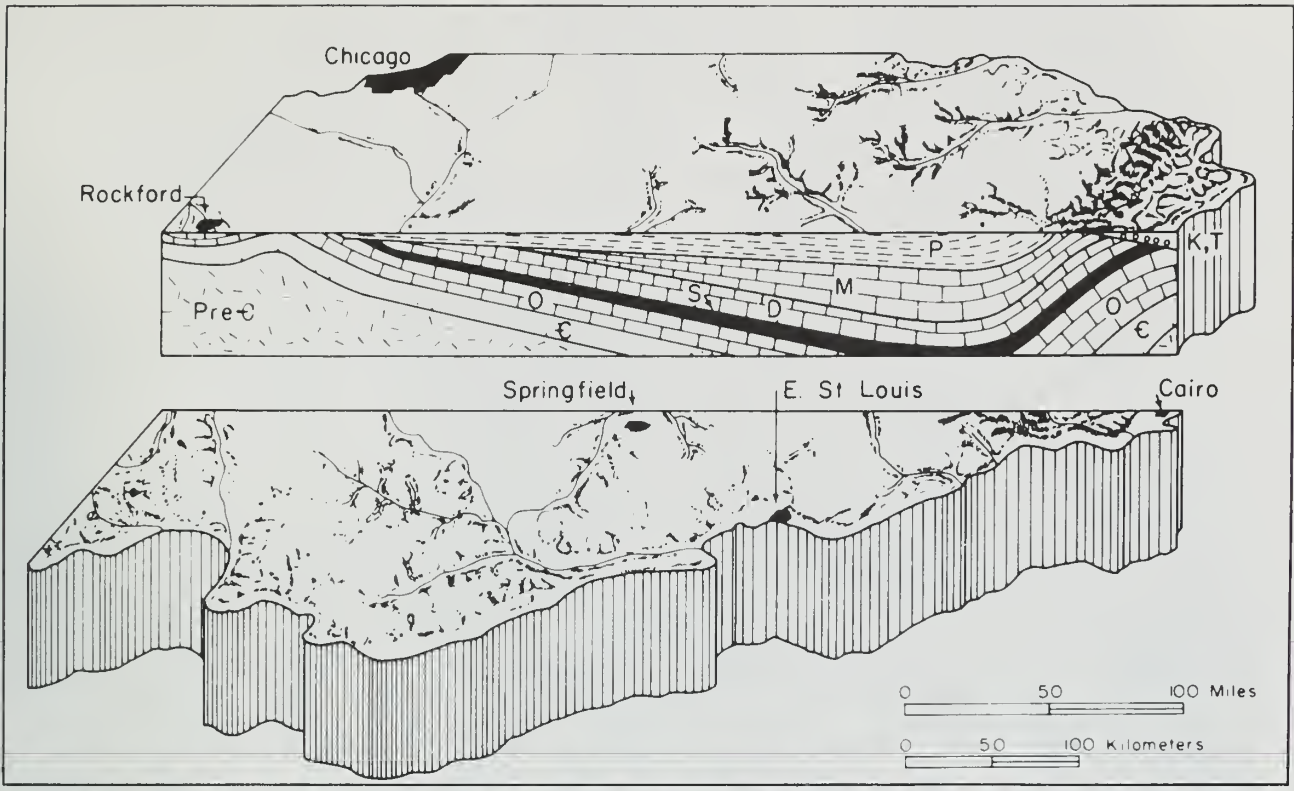


Figure 2 Stylized north-south cross section shows structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks is greatly exaggerated, and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks, Precambrian (Pre-C) granites, form a depression filled with layers of sedimentary rocks of various ages: Cambrian (C), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). The scale is approximate.

weathering and was at least partly eroded away before the overlying formation was deposited. The fossils and other evidence in the formations indicate that there was a significant gap between the time when the lower unit was deposited and the time when the overlying unit was laid down. This type of contact is called an unconformity. Where the beds above and below an unconformity are essentially parallel, the unconformity is called a disconformity; where the lower beds have been tilted and eroded before the overlying beds were deposited, the contact is called an angular unconformity. (Unconformities are shown as undulating lines across the Rock Unit column and by "U" in the contact lines in the General Description column of fig. 1).

Joliet is situated on the Kankakee Arch, a broad, gently sloping arch of Paleozoic strata that trends southeastward from the Wisconsin Arch to the Cincinnati Arch (fig. 3). This structural feature separates the present-day Michigan Basin on its northeast flank from the Illinois Basin on its southwest flank.

Following the Paleozoic Era, during the Mesozoic and Cenozoic Eras and before the onslaught of glaciation 1 to 2 million years ago, the surface of the land that is now Illinois was exposed to weathering and erosion, which produced a surface of low relief across the gently tilted rock formations. Scouring and scraping of the old erosion surface by the glaciers that repeatedly advanced across the region during the last 1 to 2 million years produced a relatively flat surface with only a few scattered bedrock hills and shallow valleys. All except the Cambrian strata were exposed to this erosion.

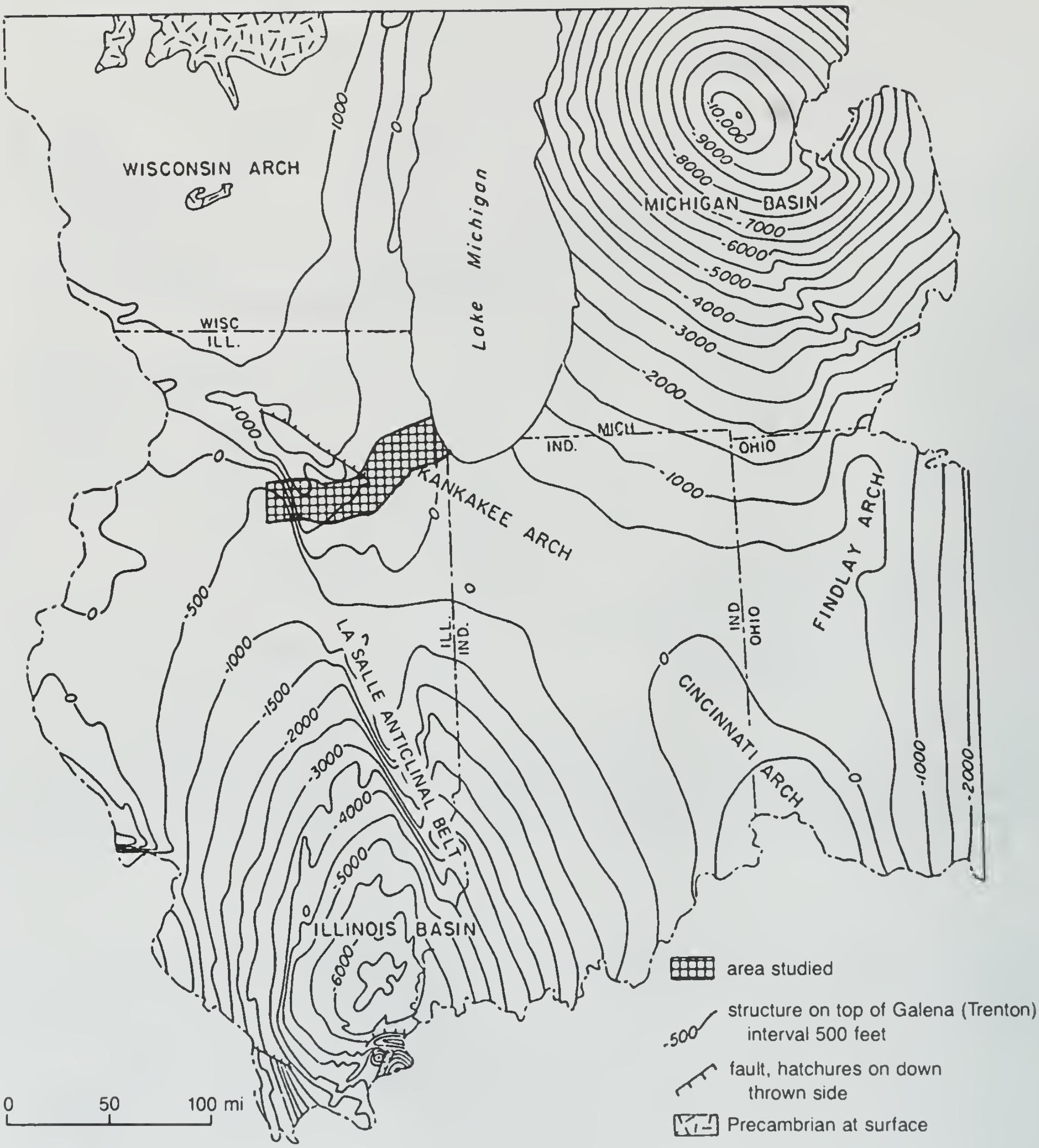


Figure 3 Regional structural features affecting the study area.

Figure 4 shows the distribution of the bedrock systems in Illinois as they would appear if all the glacial deposits were scraped off. The thickness of sediments left by the glaciers (glacial drift) ranges from a few feet to more than 100 feet over much of the area, and bedrock exposures are essentially limited to isolated outcrops along the Des Plaines River and its tributary stream cuts, highway and railroad cuts, and quarries. Rocks of the Silurian System (figs. 1 and 4) occur at or just below the surface over most of the field trip area. Because the Silurian strata have a slight dip eastward, successively older formations are exposed at the surface toward the west. Silurian rocks are rarely exposed at the surface east of the quarries near Joliet, Lockport, and Lemont. Thin-bedded, very cherty Racine Dolomite occurs along Fraction Run in Dellwood Park south of Lockport. Near Joliet, the Racine has been

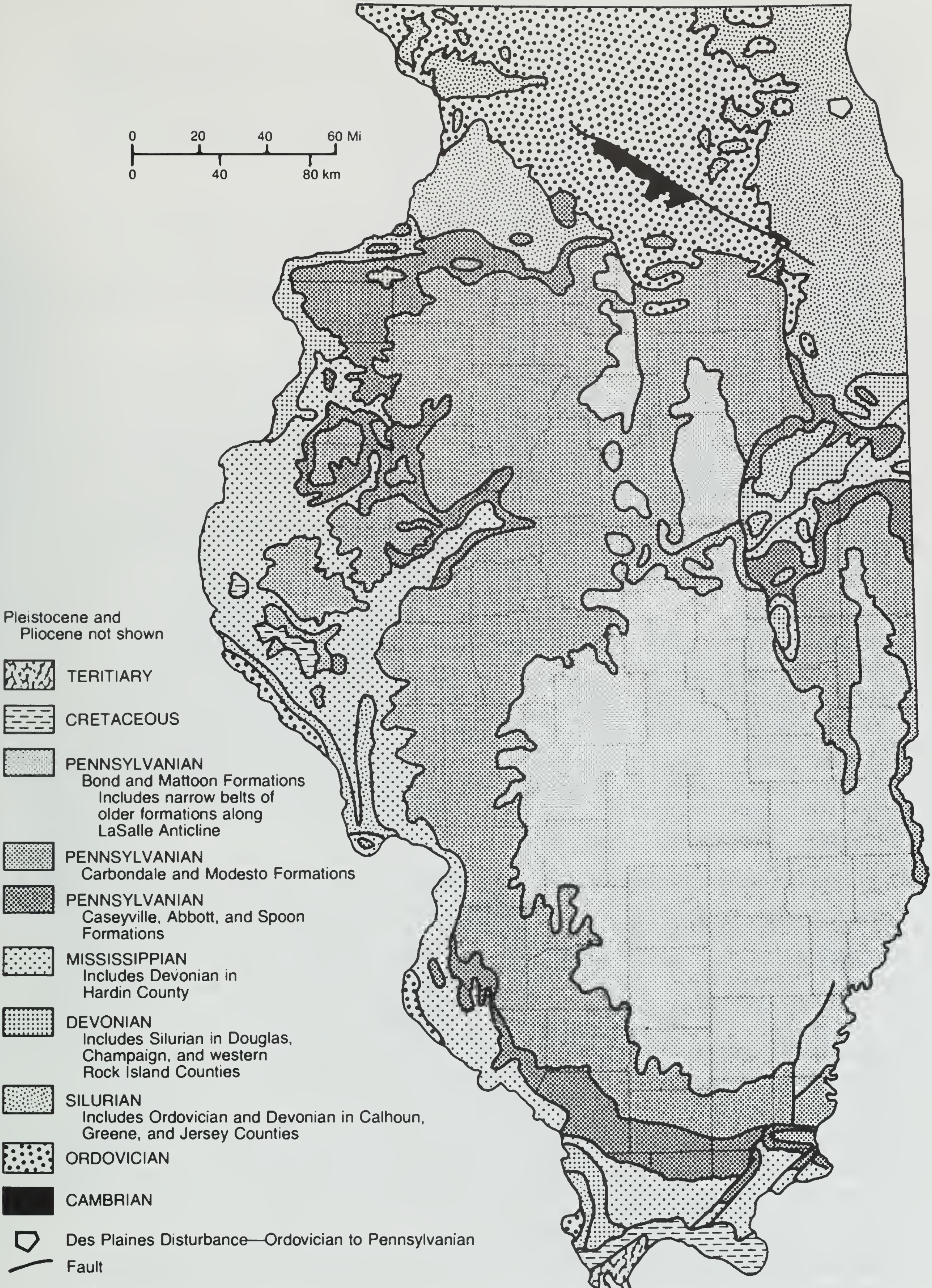


Figure 4 Geologic map of Illinois.

eroded from the top of the section, and the Sugar Run or Joliet Dolomites form the bedrock surface. At National Quarry south of I-80 on the south side of Joliet, the Silurian Sugar Run, Joliet, Kankakee, Elwood, and Wilhelmi Formations are exposed. The sump in the bottom of this quarry exposes the Fort Atkinson Limestone and Scales Shale of the Upper Ordovician Maquoketa Group. With the exception of the basal Wilhelmi, the Silurian formations of the area consist primarily of the carbonate rock called dolomite.

Southwestward from Joliet, Ordovician rocks of the Maquoketa Group are found near Channahon. Here the southeastern extension of the Sandwich Fault Zone meets the crest of the Kankakee Arch (see Structural Setting and Tectonic History below). Some of the Sandwich faults can be seen at Channahon Mound where the Ordovician Fort Atkinson Limestone and every Silurian formation of northeastern Illinois can be recognized in the fault zone complex.

Small areas of Pennsylvanian Spoon Formation are preserved at the bedrock surface in the southwestern part of the field trip area. More extensive areas of these rocks lie a few miles to the west and to the south. Mississippian and Pennsylvanian rocks were identified in cores from holes drilled into the Des Plaines Disturbance structure about 35 miles north of Joliet (fig. 4) (Emrich and Bergstrom 1962, Reinertsen 1987C). This strongly indicates that Mississippian and Pennsylvanian strata at one time extended across the Chicago area. Indirect evidence from the ranks of coals in La Salle and Grundy Counties indicates that perhaps 3,000 feet or more of Late Pennsylvanian and younger strata once covered northern Illinois (Damberger 1971); subsequent erosion has stripped them away.

Quaternary Geology Continental glaciers—massive sheets of ice hundreds of feet thick—flowed slowly southward from Canada about 1.6 million years ago during the Pleistocene Epoch, the period commonly referred to as the Ice Age (see *Pleistocene Glaciations in Illinois* in the appendix). The last of these glaciers melted from northeastern Illinois near the close of Wisconsinan time, about 13,500 years before the present (B.P.). Although ice sheets covered parts of Illinois several times during the Pleistocene Epoch, the continental glaciers reached their southernmost extent in North America during the Illinoian glaciation around 270,000 years B.P. From centers of snow and ice accumulation in Canada, the glaciers extended as far south as northern Johnson County, about 280 miles south-southwest of here (fig. 5).

Until recently, glaciologists had assumed that ice thicknesses of a mile or more were reasonable for these glaciers. However, the ice may have been only about 2,000 feet thick maximum in the Lake Michigan Basin and on the order of 700 feet thick across most of the land surface. That conclusion is based on several lines of research evidence, including the degree of consolidation and compaction of rock and soil materials that must have been under the ice; comparisons between the inferred geometry and configuration of the ancient ice masses and those of present-day glaciers and ice caps; comparisons between the mechanics of ice-flow in modern-day glaciers and ice caps and those inferred from detailed studies of the ancient glacial deposits; and the amount of rebound of the Lake Michigan Basin from being depressed beneath the mass of the glacial ice. The ice of the different glaciations was active and thick enough to intensely scour and remove part of the bedrock surface. Much of the evidence for Illinoian and pre-Illinoian glaciations in the northern part of the state also has been removed by the effects of the subsequent Wisconsinan glaciation. The last major glacial advance occurred during Wisconsinan Woodfordian time about 22,000 years before present (B.P.). Ice from an accumulation center in Labrador slowly flowed southward through the Lake Michigan Basin to form the Lake Michigan Glacial Lobe that spread out across northern Illinois. Figure 6 shows the classification of the Pleistocene materials in the Chicago/Joliet area.

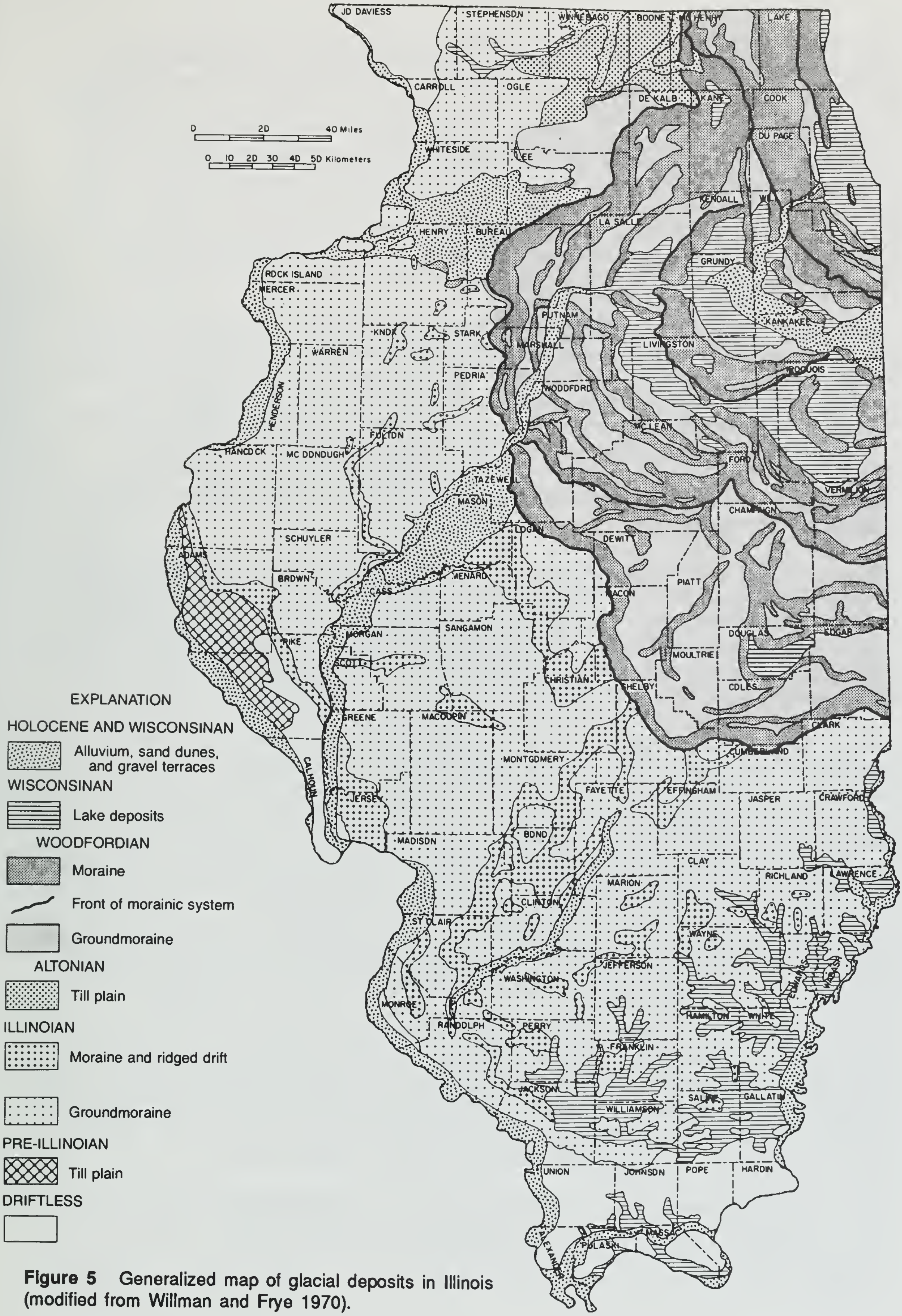


Figure 5 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

The present landscape in the Joliet area is largely the result of deposition and erosion during the Woodfordian Substage of the Wisconsinan Glacial Stage. The Woodfordian surface and deposits have been modified somewhat by further erosion and deposition during the Holocene Stage, after the last glaciers melted away. The Woodfordian glacier reached its maximum westward extent about 21,000 years B.P., when it reached beyond Hennepin in Putnam County to block the ancient Mississippi River from its ancestral course south of the "great bend" of the present-day Illinois River. After establishing the Mississippi in its modern course, the ice front melted back. Whenever the rate of melting was approximately equal to the rate of forward movement of the ice mass, the ice front was relatively stationary. In this way, successive end moraines were deposited; about 20 span the Illinois Valley. (See *Pleistocene Glaciations in Illinois* in the appendix for a discussion of moraine formation.)

Water from rapid melting of the ice front eastward from near Lockport about 15,500 years B.P., combined with huge volumes of meltwater from several hundred miles of ice front in Michigan, Indiana, and Illinois, accumulated in the Kankakee Valley, creating what is referred to as the Kankakee Flood. Because the outlet afforded by the Illinois Valley was not adequate to accommodate the great volume of meltwater, large areas of uplands between the moraines were flooded, forming Lake Wauponsee east of the Marseilles Morainic System. When the lake level finally topped a low sag in the Marseilles moraine crest, meltwater quickly eroded a channel westward. This channel was rapidly deepened and widened as the lake drained.

After the ice front melted eastward from the Joliet area, additional surges of ice produced moraines to the east. When the glacier that had deposited the Tinley Moraine began to melt back from that moraine about 14,500 years B.P., the proglacial Lake Chicago was formed between the melting ice front and the back slope of the moraine. Initially a crescent-shaped body of water around the ice front, this lake eventually expanded to cover much of the area that is now Chicago. As the ice margin continued to melt, the lake expanded northward.

Lake Chicago drained by way of an outlet through the Valparaiso and Tinley Moraines southwest of the present site of Chicago. This outlet, the "Chicago Outlet," consisted of two channels (the Des Plaines and Sag Channels) that crossed the Tinley and Valparaiso moraines and converged near Sag Bridge to form a single channel, the Des Plaines Valley. This channel emerges from the Valparaiso Morainic System near Romeoville and flows approximately 20 miles southwestward, where it is joined by the Du Page River about 4 miles upstream from the confluence with the Kankakee River. The Illinois River is formed by the confluence of the Des Plaines and Kankakee Rivers at mile post 273 (0 mile post is at the Illinois/Mississippi confluence at Grafton). The Des Plaines River probably originated as a subglacial channel while the Lemont Drift was being deposited in the Chicago area, and it persisted as an outlet for meltwater while the Valparaiso and younger moraines formed.

About 13,500 years B.P., the Woodfordian ice front melted back from Illinois into the Lake Michigan Basin, but the Chicago Outlet continued to drain basin meltwater. Three high level stands of lakes in the Lake Michigan Basin occurred until shortly after 4,000 years B.P., when northern outlets were finally incised enough to lower water level below the Chicago Outlet level. After this time, water from the Lake Michigan Basin did not flow through the Des Plaines channel again until the Illinois and Michigan Canal was built.

The Des Plaines River flows on the bedrock floor of the Chicago Outlet channel as far as Joliet. From there to the head of the Illinois River, about 18 miles downstream, the Des Plaines occupies a shallow trench cut into bedrock.

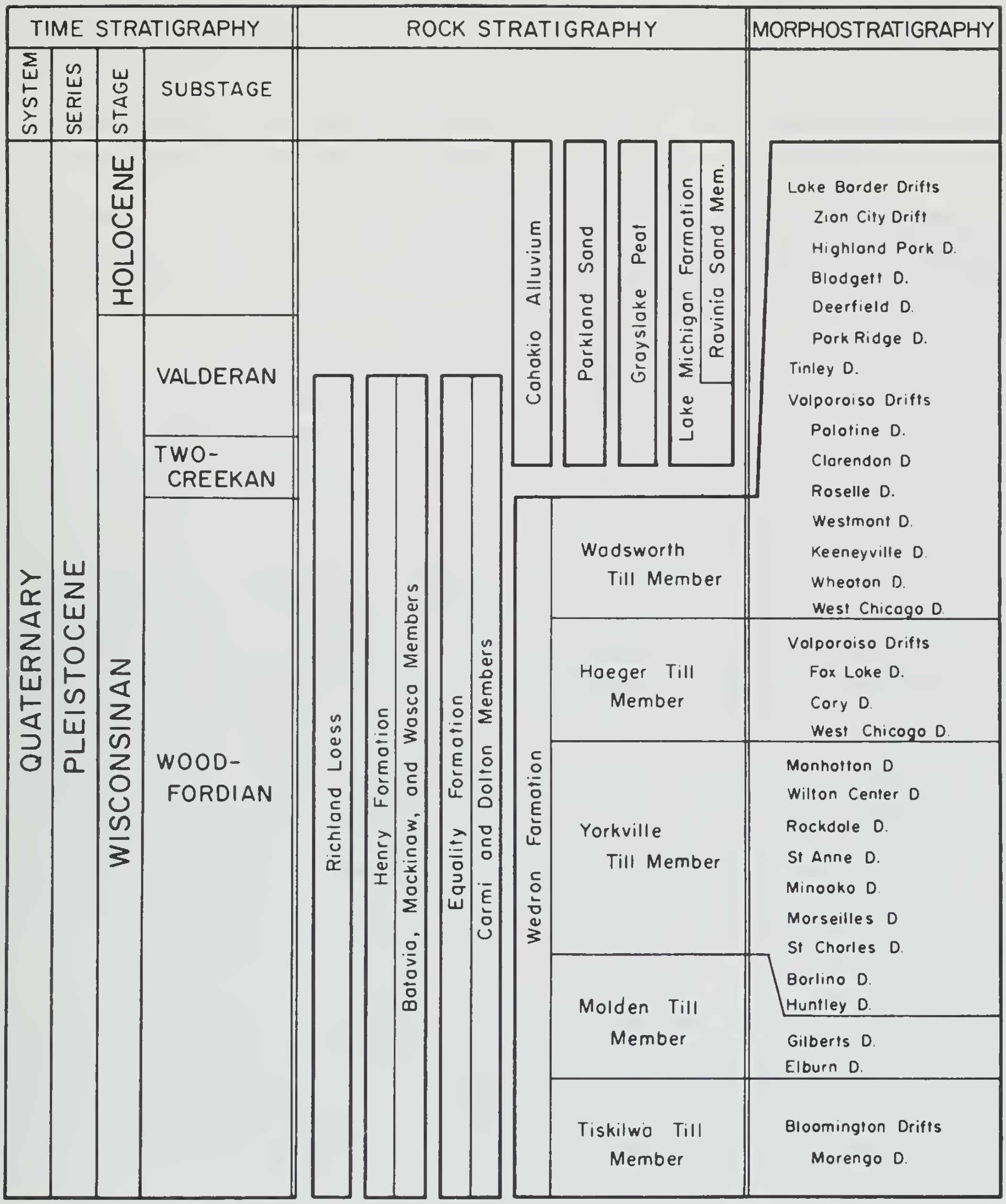


Figure 6 Classification of the Pleistocene rocks of the Chicago area (after Willman and Frye 1970).

Structural Setting and Tectonic History Because Mesozoic and most Cenozoic rocks are absent from the stratigraphic record of northern Illinois, the details of the tectonic history (the history of the Earth's crustal movements) of the region during the last 300 million years is only partially known and must be inferred from evidence in other places. A great deal is known, however, about the tectonic history of the Paleozoic Era.

A minor unconformity separates the Cambrian (Croixan) and Lower Ordovician (Canadian) rocks in northeastern Illinois. After the Lower Ordovician sediments were deposited, the tectonic (vertical or tilting) movements that disturbed major areas in the eastern part of the continent caused uplift, warping, and erosion here. As a result, the basal Middle Ordovician (Champlainian) St. Peter Sandstone was deposited over the truncated ends of the upwarped

and eroded Lower Ordovician rocks. Just north of the Joliet area, the Lower Ordovician rocks are completely eroded away and the St. Peter Sandstone directly overlies Cambrian rocks. Willman (1971) notes that Lower Ordovician rocks are again present north of the Chicago area. He suggests that this "extra" erosion in the Joliet area may indicate an early movement along the Kankakee Arch (fig. 4). A widespread minor unconformity occurs at the base of the Upper Ordovician (Cincinnatian) rocks, but the surface of the unconformity is almost flat, only slightly truncating the Middle Ordovician strata. The end of Ordovician time, however, was marked by uplift and the erosion of valleys as much as 150 feet deep in the Upper Ordovician Maquoketa Group shale. These valleys were filled with early Silurian sediments, but there is only slight evidence of unconformity in the sediments that occur between the valleys.

Silurian and Lower Devonian strata appear to be in conformable contact in northeastern Illinois, and deposition of these sediments seems also to have been continuous southward in the area of the Illinois Basin. However, as a result of tectonic movements in the Appalachian region that caused tilting, uplift, and erosion in parts of Illinois, Middle Devonian sediments were deposited across the truncated ends of Lower Devonian, Upper Silurian, and some of the Middle Silurian rocks north of central Illinois.

In areas where this pre-Middle Devonian erosion surface was especially deeply eroded, the Lower Devonian and Silurian rocks are completely absent, and Middle Devonian rocks rest directly on Upper Ordovician strata. Although Middle Devonian strata occur both north and south of the Chicago area, these rocks are not present in the Chicago/Joliet area. However, remnants of Upper Devonian black shale have been found in scattered pockets on top of the Silurian throughout the area, and rocks of Upper Devonian and Mississippian age rest directly on Silurian strata in fault blocks of the Des Plaines Disturbance. The absence of Middle Devonian strata in the Chicago/Joliet region can be explained by either of two hypotheses: (1) the Chicago area remained above sea level following the pre-Middle Devonian uplift and no Middle Devonian rocks were ever deposited, or (2) Middle Devonian rocks were deposited, then eroded away before or during Upper Devonian time. Available evidence does not allow us to eliminate either hypothesis. In either case, the observed relationships indicate uplift of the Kankakee Arch around Middle to Late Devonian time.

Although the unconformity between Middle and Upper Devonian strata is significant here in northeastern Illinois, in most of the state there was essentially continuous deposition from Devonian into Mississippian time. However, the contact between the Mississippian System and the overlying Pennsylvanian System is recognized as one of the major unconformities in the state. This sub-Pennsylvanian unconformity resulted from regional uplift and upward warping of the Kankakee Arch and other anticlinal structures in Illinois.

These movements continued into early Pennsylvanian time and caused deep erosion, during which older rocks were removed from wide areas in the northern part of the state. Later subsidence of the area of the present Illinois Basin resulted in deposition of successively younger Pennsylvanian sediments across the upturned edges of the Mississippian, Devonian, Silurian, and part of the Ordovician rocks around the northern rim of the Illinois Basin (onlap). Just to the southwest of the Joliet field trip area, Pennsylvanian rocks directly overlie Ordovician and Silurian strata, but elsewhere in the area Pennsylvanian rocks generally have been eroded away. Although no major unconformities occur within the Pennsylvanian System in Illinois, the oldest Pennsylvanian rocks were deposited only in southern Illinois.

At the end of the Paleozoic Era, the Chicago/Joliet area was uplifted and warped during the major tectonic events that folded and faulted the formations in the Appalachian Mountains. The Kankakee Arch was again uplifted, and the Pennsylvanian strata, possibly exceeding

3,000 feet in total thickness, were eroded from most of this area. There is no evidence that any younger sediments accumulated during the long time interval between the deposition of the latest Pennsylvanian rocks and the deposition of the Pleistocene glacial drift. This "sub-Pleistocene unconformity," the bedrock surface in Illinois, truncates all the Tertiary, Cretaceous, and Paleozoic rocks down to the Upper Cambrian rocks exposed at the bedrock surface in the Sandwich Fault Zone.

Because the Joliet area is close to the crest of the broad, gently warped Kankakee Arch, the bedrock appears to be nearly horizontal or to have only a slight eastward dip. The broad regional movements that formed the Kankakee Arch were also accompanied by minor local warps and faults. Faults with vertical displacements of a few feet to as much as 20 feet are fairly common across the region, but there is no evidence that these faults have been active for hundreds of thousands of years.

Major faults occur not only in the Des Plaines Disturbance, noted previously, but also in the Sandwich Fault Zone located in the southwestern part of the field trip area (figs. 3 and 4). This major fault zone extends from near Oregon in Ogle County southeastward for a distance of about 80 miles to the vicinity of Manhattan, about 10 miles south-southeast of Joliet. We know that the faults that make up the Sandwich Fault Zone are younger than Silurian age because Silurian rocks are broken by them. Although Pennsylvanian strata have been completely eroded from the vicinity of the Sandwich Fault Zone, major folding and faulting west and south of the Chicago/Joliet area involved Pennsylvanian rocks. The Sandwich Fault Zone, therefore, is likely to be post-Pennsylvanian in age and related to the major tectonic disturbance at the end of the Paleozoic Era.

Physiography Physiography is the study and classification of the surface features of the Earth based on similarities in geologic structure and the history of geologic changes. The physiographic contrasts between various parts of Illinois are due to a number of factors and conditions, such as bedrock surface topography, the extent of the various glaciations, differences in glacial topography, differences in age of the uppermost glacial drift, and the effects of erosion on the surface.

The Joliet field trip area is situated in the northeastern part of the Till Plains Section, the division of the Central Lowland Province (fig. 7) that embraces about four-fifths of Illinois. This section is characterized by broad till plains, which are relatively uneroded (a youthful stage of erosion) in contrast to the maturely eroded Dissected Till Plains on older drift-sheets to the west. This section has seven subdivisions: the Bloomington Ridged Plain, Galesburg Plain, Green River Lowland, Kankakee Plain, Mt. Vernon Hill Country, Rock River Hill Country, and the Springfield Plain.

The Joliet field trip area is located in the northern part of the Kankakee Plain adjacent to the Wheaton Morainal Country of the Great Lakes Section. The northwestern-to-southern boundary of this region is the Bloomington Ridged Plain. Leighton and others (1948) describe the Kankakee Plain as a level to gently undulatory plain, with low morainic islands, torrent bars, and dunes. It is partially fluvio-lacustrine in origin; that is, part of its sediments were deposited under alternating or overlapping lacustrine (lake) and fluvial (stream) conditions. Lakes that occurred in the Kankakee Plain were temporary expansions of glacial floods and did not extensively alter the plain's surface by deposition or erosion, except along the courses of strong torrents. Most of the area now is poorly drained by shallow, low-gradient streams. The Des Plaines and Kankakee Rivers, which occupy glacial sluice-ways, are the two major streams of the area. In this region, the drift ranges from thick to thin and in many areas barely conceals the bedrock surface.

Figure 7 Physiographic divisions of Illinois.

Drainage The Joliet field trip area is a few miles west of the drainage divide between the Mississippi Basin and the Great Lakes-St. Lawrence system. Joliet and its immediate environs are drained by the Des Plaines River and its tributaries, of which the Du Page River is the largest.

The more important Des Plaines tributaries are Long Run, Fiddyment Creek, Fraction Run, Spring and Hickory Creeks, and Sugar Run, all of which lie east of the river. Rock Run used to flow into the river about 4 miles below Joliet, but its course was altered to flow into the Illinois and Michigan (I & M) Canal. Spring Brook and Lily Cache Creek are the more important tributaries to the Du Page River. Aux Sable Creek, west of Minooka, flows into the Illinois River.

Relief The highest land surface along the Joliet field trip, slightly more than 760 feet mean sea level (m.s.l.), occurs about one-half mile south-southeast of Stop 3. The lowest elevation is slightly less than 495 feet m.s.l. and is just downstream from the Aux Sable Creek-Illinois River confluence. Thus the maximum relief along the field trip route is somewhat more than 265 feet. The maximum local relief is more than 110 feet along the bluffs in Joliet and at Kankakee Bluffs overlooking the head of the Illinois River.

Mineral Resources

Groundwater Groundwater is a mineral resource frequently overlooked in assessments of an area's natural resource potential. The availability of this mineral resource can be essential for orderly economic and community development. More than 48 percent of the state's 11 million citizens depend on groundwater for their water supply. Groundwater is derived from underground formations called aquifers. An aquifer is a body of rock that contains enough water-bearing porous and permeable materials to release usable quantities of water into an open well or spring. The water-yielding capacity of an aquifer can only be evaluated by constructing wells into it. After construction, the wells are pumped to determine the quality and quantity of groundwater available for use.

Northeastern Illinois is underlain by four major aquifer systems that are separated from each other on the basis of their hydrogeologic properties and the source of recharge. The aquifer systems are (1) the glacial drift, (2) the shallow bedrock, (3) the deep Cambrian-Ordovician bedrock, and (4) the deep Cambrian bedrock.

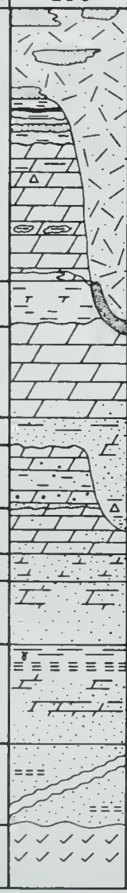
The glacial drift aquifer system, known as the Prairie Aquigroup, consists only of the unconsolidated materials that overlie bedrock. It is recharged by local precipitation and thus is susceptible to surface contamination. A spring in Pilcher Park, Joliet (NE NE NW SE Sec 7, T 35 N, R 11 E, 3rd P.M; Joliet 7.5-minute Quadrangle), furnishes natural spring water for area residents.

The shallow bedrock aquifer system consists generally of those bedrock formations that directly underlie the glacial drift. These formations consist mostly of Silurian dolomites that are relatively nonporous. They contain water only in open joints and cracks and also are recharged by local precipitation. The only filtering of the recharge water is by the overlying glacial deposits. Where recharge is directly into the rock units, there is little if any filtering of deleterious materials.

The two deep bedrock aquifer systems are made up mostly of relatively porous sandstones. They receive most of their recharge from regions where they are exposed or where they directly underlie the glacial drift miles to the west and north of the study area. Between the regions where it outcrops and the field trip area, the upper bedrock aquifer system also receives some recharge water from the overlying shallow aquifer system through open joints and cracks that connect them. The water in the two deep bedrock systems has been in contact with the rocks that make up the aquifer for a relatively long time. Consequently, the water in the deep bedrock aquifer systems has had plenty of time to dissolve some of the minerals in the rocks and generally has a fairly high content of dissolved solids. Figure 8 provides more details of the aquifer systems of northeastern Illinois.

Mineral Production Of the 102 counties in Illinois, 99 reported mineral production during 1987, the last year for which totals are available. Total value of all minerals extracted, processed, and manufactured in Illinois fell to $3.22 billion—1.3 percent lower than the 1986 total. This value was the lowest on record since 1978, when the total was $3.17 billion.

Cook County ranked 7th among Illinois counties reporting mineral production during 1987. In order of their value, stone, sand and gravel, and peat were extracted; expanded perlite, slag, pig iron, secondary slab zinc, and sulfur were processed; and lime and coke were manufactured. Grundy County ranked 64th among the counties with production limited to sand and gravel. Will County ranked 18th. Stone and sand and gravel were extracted, sulfur and expanded perlite were processed, and glass was manufactured.



SYSTEM	SERIES	MEGA-GROUP	GROUP OR FORMATION	GRAPHIC LOG	THICKNESS (FEET)	DESCRIPTION	AQUIFER SYSTEMS	
QUATERNARY	PLEISTOCENE				0 - 400 +	Unconsolidated ice- and water-laid deposits, pebbly clay (till), silt. sand and gravel, generally discontinuous and interbedded; alluvial silts and sands commonly present along streams.	Glacial drift aquifer system	Sand and gravel beds serve as aquifers. Some wells yield more than 1000 gpm. Large supplies of water available from thick, relatively continuous sand and gravel deposits.
PENNSYLVANIAN					0 - 175	Shale; sandstones, fine grained; limestones; coal; clay.	Shallow bedrock aquifer system	Fractured beds yield small supplies locally.
MISSISSIPPIAN* DEVONIAN; SILURIAN	NIAGARAN				0 - 400 +	Dolomite, very pure to very silty, cherty; shale partings; thin shales and argillaceous beds frequently present in lower parts of Silurian dolomite.		Not consistent; some wells yield more than 1000 gpm. Crevices and solution channels more abundant near bedrock surface.
SILURIAN	ALEXANDRIAN				0 - 165	Upper and middle units—shale, light gray to green, plastic to brittle, some dolomite, silty; dolomite, mostly silty, argillaceous; minor limestone.		Yields water from fractured beds. Shales. particularly in lower unit, act as confining beds at the base of the shallow bedrock aquifer system.
ORDOVICIAN	CINCINNATIAN		Maquoketa		0 - 250 +	Lower unit—shale, dark gray, black, brown, plastic to brittle; some dolomite in upper part; silty, argillaceous.		
ORDOVICIAN	CHAMPLAINIAN	OTTAWA	Galena Platteville		150 - 350 +	Dolomite, cherty; sandy at base; limestone; shale partings.	Deep bedrock aquifer systems: Cambrian-Ordovician aquifer system	Where below shales, development and yields of crevices are small; where not capped by shales, dolomites are fairly permeable.
ORDOVICIAN	CHAMPLAINIAN		Glenwood St. Peter		75 - 650	Sandstone, fine to coarse grained; shale at top; locally cherty red shale at base.		Glenwood-St. Peter Sandstone. Small to moderate quantities of water. T probably about 15% of that of Cambrian-Ordovician aquifer system.
ORDOVICIAN	CANADIAN	KNOX	Prairie du Chien		0 - 340	Dolomite, sandy, cherty, interbedded with sandstone.		Crevices in dolomite and sandstone generally yield small amounts of water. Potosi dolomite locally well creviced and partly responsible for exceptionally high yields of several deep wells. T probably about 35% of that of Cambrian-Ordovician aquifer system.
CAMBRIAN	CROIXAN	KNOX	Eminence Potosi		0 - 225	Dolomite, white, fine grained, sandy at base; drusy quartz.		
CAMBRIAN	CROIXAN		Franconia		45 - 175	Sandstone, dolomite, and shale, glauconitic, green to red, micaceous.		
CAMBRIAN	CROIXAN		Ironton Galesville		103 - 275	Sandstone, fine to medium grained, well sorted, upper part dolomitic.		Ironton-Galesville Sandstone. Most productive part of Cambrian-Ordovician aquifer system. T probably about 50% of entire system.
CAMBRIAN	CROIXAN		Eau Claire		235 - 450	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic; dolomite, sandy.		Shales generally not water yielding; act as confining bed at the base of the Cambrian-Ordovician aquifer system.
CAMBRIAN	CROIXAN	POTSDAM	Mt. Simon		2000 ±	Sandstone, coarse grained, white, red in lower half; lenses of shale and siltstone, red, micaceous.	Mt. Simon aquifer system	Mt. Simon Sandstone. Data sparse; probably less permeable than Ironton-Galesville; quality of water deteriorates with depth.
PRECAMBRIAN						Not penetrated by wells in Chicago area. Nearby wells encounter red or gray granite or similar rocks.		

* Mississippian rocks present in Des Plaines Disturbance.
Devonian rocks present as crevice fillings in Silurian rocks.

Modified from Suter et al., 1959, p. 24; Zeizel et al., 1962, p. 14; Walton and Csallany, 1962, p. 9.

Figure 8 Stratigraphy and aquifer systems of northeastern Illinois with hydrologic properties of main water-yielding units of the bedrock (from Hughes et al. 1966).

REGIONAL HISTORY

Illinois and Michigan Canal The feasibility of digging a canal to connect Lake Michigan and the Illinois River, via the Chicago and Des Plaines Rivers, was recognized early during the settlement of Illinois. As far back as 1673, Fathers Joliet and Marquette had noted the possibility of digging a canal link.

In 1829, Congress authorized the State of Illinois to build a canal to join Lake Michigan and the Illinois River at an estimated cost of $4 million. Work began in 1836, but the 1837 business panic affected the project, and construction was stopped in 1839. Work resumed later, but in 1843 after almost $5,000,000 had been spent, the original lake-level canal program was abandoned in favor of a cheaper, shallow-cut canal with locks. When the canal was finally completed in 1848, it extended 95 miles from La Salle to a point in Chicago that is now near Ashland Avenue, just north of I-55.

Illinois mineral producers were among the prominent users of the canal. Coal could be shipped easily to eastern markets, and building stone, sand, and gravel were shipped from place to place along the canal. Lumber, salt, agricultural implements, and steel tracks for railroads were imported into Illinois via the canal.

The Illinois and Michigan Canal was instrumental in turning Chicago into a major transportation hub by linking the central part of the state to the industrialized east via the Great Lakes and the Erie Canal. After the railroads had been constructed, however, their competition led to a sharp slump in the use of the canal. Additional competition from the larger Chicago Sanitary and Ship Canal in the 1890s finally put the I & M Canal out of business, and it rapidly deteriorated into discontinuous fetid sloughs that became local trash heaps.

The Illinois and Michigan Canal National Heritage Corridor was nominated by the National Park Service (NPS) as a historic landmark in 1963. In the early 1970s, the State of Illinois designated canal lands between Joliet and La Salle as the Illinois-Michigan Canal State Trail and had begun to make substantial improvements along that portion. The corridor was first seriously studied by the NPS in 1979 along with an Open Lands Project inventory. In 1980, after a series of articles in the Chicago Tribune, the Illinois congressional delegation sponsored a bill to make the canal a national park. This was followed by the completion of the NPS feasibility study. Open Lands Project sponsored a number of town meetings throughout the area encouraging Illinois Valley industry to become involved. With so many segments of the population involved, new federal legislation was introduced into Congress in 1982. The 98th Congress passed the Illinois and Michigan Canal National Heritage Corridor Act of 1984 in August. In 1985, under that legislation, the NPS was provided with funds to produce a geological inventory of the corridor and that year contracted with the Illinois State Geological Survey to do so. A report was submitted to the NPS in the fall of 1986.

The Illinois-Michigan Canal National Heritage Corridor is a new kind of national park. It directs attention to geology, archeology, prehistory, history of settlement, and history of industrial development, as well as economic revitalization. The I-M Canal Corridor thus represents a zone of special federal interest for fostering restoration and for recreation through open land preservation. For the first time, however, the Department of the Interior also includes economic development as one of the important reasons for park designation. In addition, the corridor represents a trend toward bringing national parks to the people, especially where national, cultural, and recreational resources are in the midst of urbanized regions.

Quarry History of the Lower Des Plaines Valley Stone, one of Earth's most abundant and useful building resources, has been used by man from earliest history to the present. Because of the durability and availability of this naturally occurring material, early civilizations made wide use of it in constructing temples, walls, and pyramids.

Like the ancient cultures before us, the "New World" used natural stone for its foundations. Limestone and dolomite were of special importance, providing building stone and lime, used in mortar and later, in cement. Most permanent structures were made of stone, usually quarried rock. If quarried rock was unavailable locally, fieldstone of glacial cobbles and boulders was used instead.

Quarried stone was labor intensive and costly. This prohibited all but the wealthiest individuals and businesses from constructing buildings made entirely from cut stone. If a landowner was fortunate enough to have outcrops of quality stone on his property, he could quarry the stone and build at low cost; thus, buildings of all types were constructed of stone.

Stone construction proved to be both practical and aesthetic. Strong stone foundations added stability to wood structures. The durability and insulating properties of stone had many practical benefits. Because they were attractive, stone buildings were welcomed as an alternative to wood or brick structures.

Some of the earliest recorded uses of building stone in Illinois were the 1753 reconstruction of Fort de Chartres from material from bluffs 3 miles to the east of it, and in the foundation of the Pierre Menard House in 1802, both in Randolph County of southwestern Illinois. As settlement continued through the early 1800s, additional stone deposits were discovered and, as the transportation network improved, so did the demand for cut stone. This provided enough work to support specialized stone cutters and produce a rapidly expanding building stone trade.

The stone trade was especially successful in northeastern Illinois as there was both a high demand for stone products and a readily available source from the rock of Silurian age that underlies the region. Quarries were opened in Chicago in the 1830s; the stone made excellent lime, but was not suitable for veneer or solid block. It was used mainly for rough foundation stone.

Extensive quarriable dolomite of high quality, that was well bedded, smooth textured, and of variable bed thickness, occurs in the Silurian bedrock along the Des Plaines River Valley west of Chicago. This stone was used only locally during the 1830s and 1840s. However, the opening of the I&M Canal in 1848 provided a major boost to the use of Silurian rocks from existing quarries in the Des Plaines Valley. The stone could be easily and cheaply transported directly to the center of Chicago. The building of the canal also resulted in the discovery of additional quarry sites near the small community of Athens, now known as Lemont. The stone here was first discovered in 1846 during canal construction, but was considered useful only for foundation use.

Throughout much of the Des Plaines Valley between Lemont and Joliet, the canal is excavated in Silurian bedrock. During canal construction, several contractors realized the economic potential of these sites, located at the very edge of a cheap transportation system. Beginning in 1851, several quarry operations began in the Athens (Lemont) area. In 1852, rock from this area was first used successfully as cut stone facing in Chicago. The success of this new product induced the rapid opening of several businesses in Chicago to sell the

"Athens Marble" exclusively. In 1869 and 1870, some 30 to 40 "marble" front buildings were constructed on State Street in Chicago; the famous Water Tower on Michigan Avenue also was constructed from Athens Marble.

Most of the quarries that opened to supply the "marble" yards of Chicago were small and short lived mainly due to poor quality stone and economic conditions. Although several quarries survived and the number of new ones steadily grew until the 1870s, by the end of the century mergers and purchases had reduced the number considerably. Many remaining firms became quite large; the giant Western Stone Company formed in 1889.

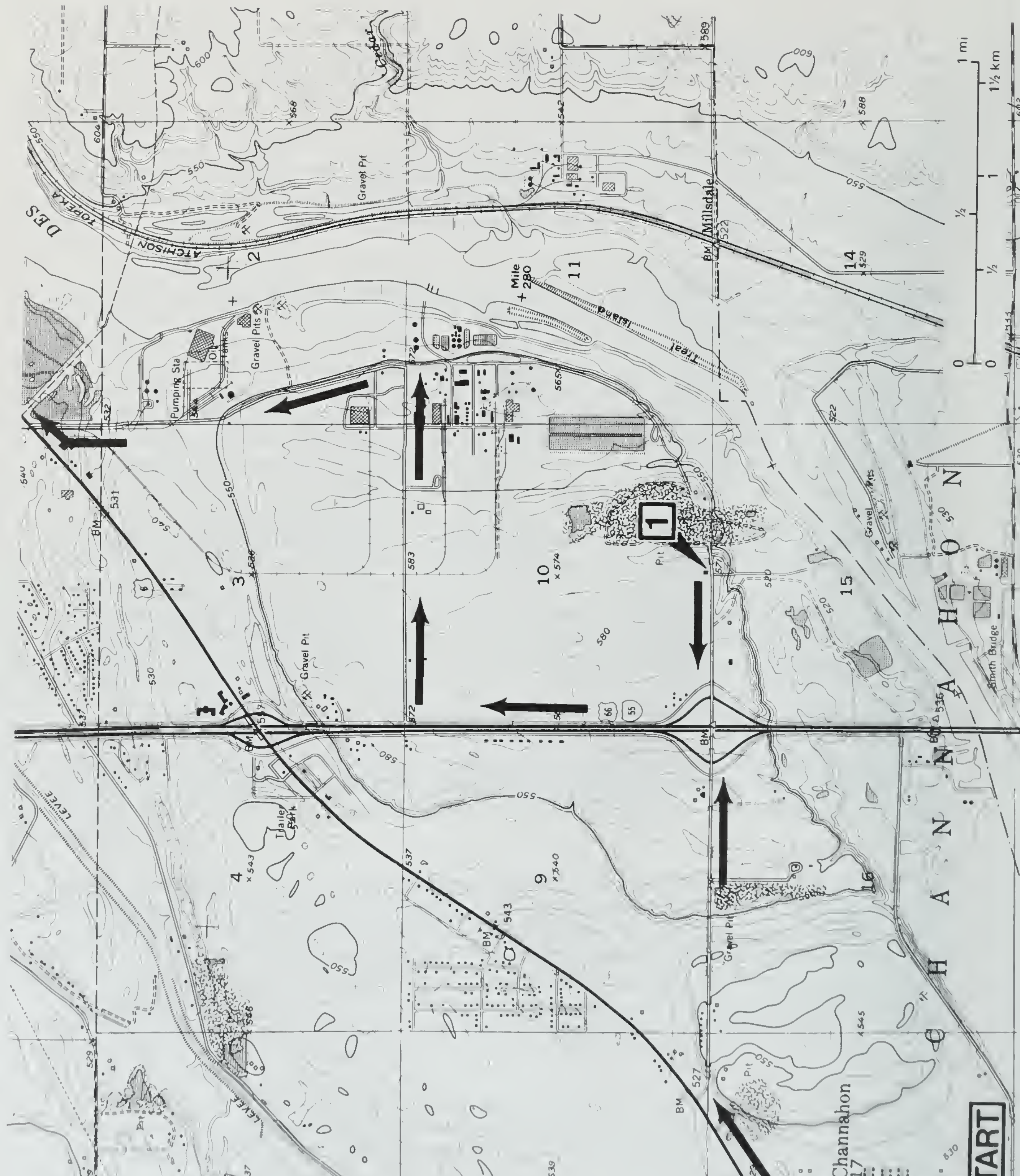
More than 50 quarries are known to have existed in the Des Plaines Valley between Sag Bridge and Joliet. Many others probably were present, but all traces have been obliterated through urban expansion, especially near Joliet.

In the Athens (Lemont) and Joliet quarries, three main stone products were produced: dimension stone, flagstone, and rip-rap and crushed stone. Dimension stone was used for rock-faced block or foundation stone, veneer, cornices, pillars, columns, and vault covers. Flagstone was a naturally splitting, uncut building stone made from fairly thin beds. Rip-rap and crushed stone were used for fill, concrete, macadam, and railroad ballast. The stone from this area was less well suited for lime than rock from Chicago. Stone quality varied between different quarries and between different beds within a quarry, depending upon which formation was present. In the Joliet-Lemont (Athens) area, most of the high-quality building stone was quarried from the Silurian Sugar Run Formation.

By the late 1880s, Athens Marble had been in use for nearly 40 years and was beginning to show signs of age. Critics began to publicize the stone's shortcomings and builders looked elsewhere for dimension stone. This created an influx of other types of stone for the building industry. Adding to the problems of the quarry operator were the adverse economic conditions, high labor costs, and the move toward unionization of the 1890s. However, the geology of the Silurian rocks was also a significant reason for the decline of the building stone industry in Illinois. The Illinois stone occurs in layers seldom more than one foot thick and may be interbedded with poor quality layers, thereby becoming more labor intensive to quarry. In the long run, it was unable to compete with the thicker bedded, purer stone from Indiana.

The Athens Marble that was used for many fine structures in Chicago and elsewhere during the mid- to late-1880s simply went out of use around the turn of the century as a building stone. It became obsolete due to changing styles and beliefs, the availability of a better quality stone, and the availability of new building materials. Fortunately, a number of gracious survivors from the heyday of Joliet limestone and Athens Marble remain as vivid reminders of the stone's widest use as a building material. In recent decades, limestone and dolomite have been almost completely replaced as a building material by a cheaper, more convenient product—concrete.

The Athens Marble, now called Lemont stone, was briefly revived in 1938-40 for use in the State Archives in Springfield, and the Natural Resources Building, headquarters of the Illinois State Geological Survey in Urbana. The stone was cut for interior use but failed to "catch on" in Chicago and other areas.


START
Channahon
Millsdale
DES
ATCHISON
TOPEKA
Gravel Pit
Gravel Pits
Pumping Sta
Trailer Park
LEVEE
Smith Bridge
Mile 280
1
1 mi
1½ km

GUIDE TO THE ROUTE

Assemble about 4 blocks south of US-6 in the Channahon Access parking lot, Illinois and Michigan Canal (Ctr. SW, Sec. 17, T34N, R9E, 3rd P.M., Will County, Channahon 7.5-minute Quadrangle [41088D2]*). The day will begin with an opportunity for you to briefly explore the old I&M Canal and locks in the immediate vicinity.

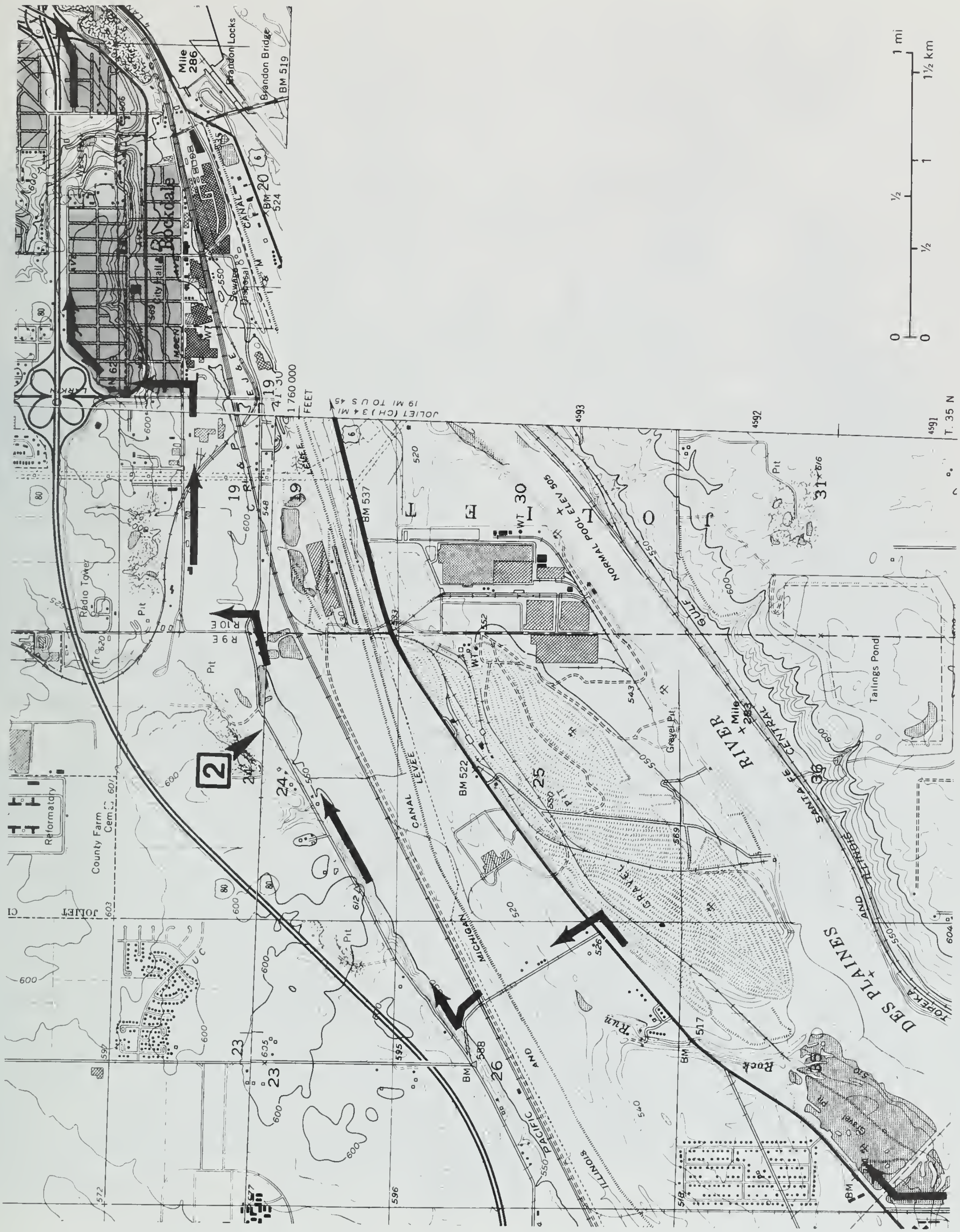
Mileage calculations will begin east of the Access entrance at the intersection of Canal and Story Streets. Please drive with your lights on while the caravan is moving. Turn them off when we park. Drive safely and stay as close as you can to the car in front of you. PARK CLOSE.

Miles to next point	Miles from start	
0.0	0.0	TURN LEFT (north-northwest).
0.35+	0.35+	STOP (1-way) at T-intersection with Eames Street and US-6. TURN RIGHT (northeast).
0.65+	1.05	Prepare to turn right.
0.1	1.15	TURN RIGHT (east) on Bluff Road.
0.5	1.65	We are crossing a north-south sag in the topography—a glacial sluiceway that briefly carried meltwater from Lake Chicago.
0.55+	2.2+	CAUTION as you approach the I-55 interchange.
0.15+	2.35+	Cross I-55. CONTINUE AHEAD (east).
0.5	2.85+	STOP at the locked gate and entrance to the Meyer Material Company. You must have permission to enter this property. Park outside the gate alongside the road. Please DO NOT BLOCK the road or gate. Inside the gate, stay together. DO NOT THROW ROCKS. DO NOT CLIMB on any rock faces or piles. Stay back from the edge.

STOP 1. We will examine a portion of the Sandwich Fault Zone from a vantage point about 0.15 mile east of the gate (SE cor. SW, Sec. 10, T34N, R9E, 3rd P.M., Will County, Channahon 7.5-minute Quadrangle [41088D2]).

* The number in brackets [41088D2] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first pair of numbers refers to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into 64 7.5-minute quadrangles; the letter refers to the east-west row from the bottom, and the last digit refers to the north-south column from the right.

0.0	2.85+	Leave Stop 1 and head west on Bluff Road.
0.25+	3.1+	CAUTION as you approach the I-55 interchange. Prepare to turn right.
0.1	3.2+	TURN RIGHT (northwest) on the access road.
0.95	4.15+	Prepare to turn right.
0.1	4.25+	T-road intersection. TURN RIGHT (east) on AMOCO Road.
0.2	4.45+	To the right is the central administrative office of the Midwestern Gas Transmission Company (TENNECO) and the Natural Gas Pipeline Company of America.
0.25+	4.75+	CAUTION: single guarded Elgin, Joliet, and Eastern Railroad (EJ&E RR) spur.
0.2	4.95+	Industrial area: Joliet Plant, AMOCO Chemicals Company.
0.45+	5.4+	Sharp LEFT TURN (north).
0.75	6.2+	CAUTION: single unguarded EJ&E RR spur.
0.1	6.35+	CAUTION: single unguarded EJ&E RR spur.
0.15	6.55+	To the right is an abandoned pit of the Chicago Gravel Company. Note the large masses of naturally cemented gravel that were left behind.
0.15+	6.7+	STOP (1-way). TURN RIGHT (northeast) on US-6.
0.7	7.4	Note the large glacial erratic to the left by the tree grove.
0.25	7.6+	Cross Rock Run.
0.4	8.0+	Prepare to turn left.
0.1	8.1+	TURN LEFT (north) on Bush Road.
0.25	8.35+	Note use of glacial erratics for decorative purposes on right.
0.1+	8.5	Cross I&M Canal.
0.05+	8.6	CAUTION: two guarded Iowa Interstate Railroad (IAIS RR) tracks (former Chicago, Rock Island, and Pacific Railroad). Ascend the north wall of the Chicago Outlet valley just ahead and prepare to turn right.
0.2	8.8	CAUTION: off-centered crossroad. Make a HARD RIGHT TURN (northeast) on Mound Road. Rough road ahead has much truck traffic.
0.95	9.75+	CAUTION: landfill entrance to left.

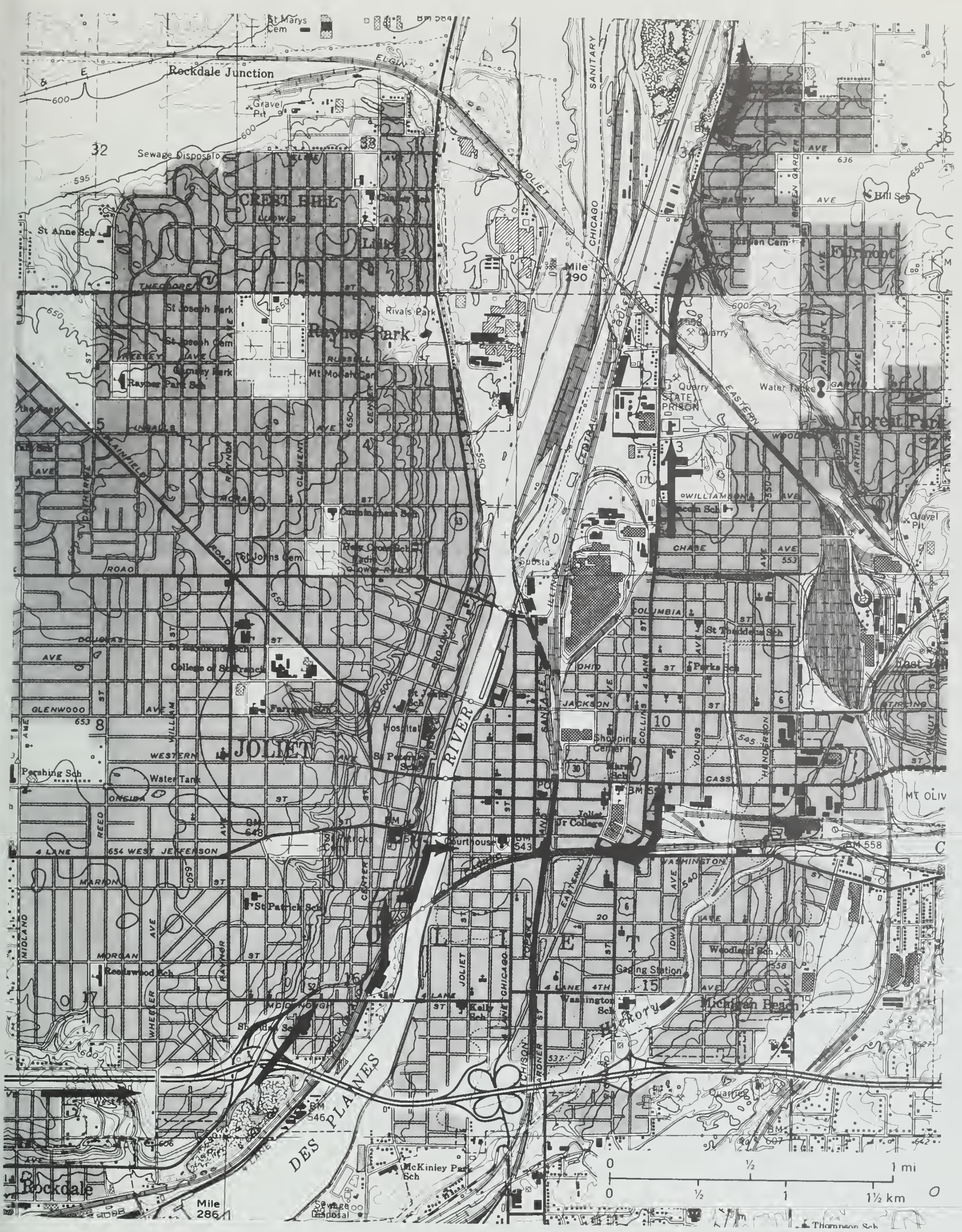


Brandon Locks
Brandon Bridge
Mile 286
BM 519
Rockdale
City Hall
Sewage Disposal
CANAL
Radio Tower
Reformatory
County Farm
JOLIET
Pit
CANAL LEVEE
MICHIGAN
ILLINOIS
PACIFIC
NORMAL POOL ELEV 505
GRAVEL
Gravel Pit
RIVER
Mile 283
DES PLAINES
SANTA FE
GULF
CENTRAL
TOPEKA
Tailings Pond
Rock Run
T. 35 N
R 9 E
1 760 000 FEET
2
1 mi
1½ km

0.05+	9.8+	CAUTION: narrow concrete-sided culvert.
0.3+	10.1+	CAUTION. Park along the roadside opposite the entrance to the Joliet Sand and Gravel Company. Please DO NOT BLOCK any gates. There may be heavy truck traffic to the landfill that we just passed. You must have permission to enter this property. Please FOLLOW DIRECTIONS and stay away from all equipment and machinery. DO NOT CLIMB on stone piles. This is NOT A STOP FOR COLLECTING ROCKS. We will walk to the east side of the operation and stay out of the pit.

STOP 2. We will discuss natural resource availability and the apparent lack of long-range planning for some human needs (entrance: NW NE NW SE, Sec. 24, T35N, R9E, 3rd P.M., Will County, Channahon 7.5-minute Quadrangle [41088D2]).

0.0	10.1+	Leave Stop 2 and CONTINUE AHEAD (east).
0.3+	10.45+	T-road intersects from left. TURN LEFT (north). As you proceed north, you can view the landfill operation around the Joliet Sand and Gravel Company.
0.2+	10.7	TURN RIGHT (east) on Moen Avenue.
0.45+	11.15+	CAUTION: unguarded EJ&E RR crossing.
0.3+	11.5+	CAUTION: stoplight at Larkin Avenue. TURN LEFT (north) uphill on Larkin/SR-7.
0.15	11.65+	Approach the I-80 interchange and prepare to turn right.
0.1+	11.75+	TURN RIGHT (east) on I-80 access ramp.
0.25	12.05+	CAUTION. MERGE LEFT onto I-80.
0.85+	12.9+	Prepare to exit I-80 at the Center Street Exit.
0.1	13.0+	BEAR RIGHT and EXIT at Center Street. As you get away from the interchange, MOVE TO THE OUTSIDE LANE.
1.0+	14.05+	Stoplight: TURN RIGHT (east) on West Marion Street. TURN LEFT (north) on Bluff Street at the bottom of the hill.
0.25	14.3+	At the north end of the parking lot on the right is an information office for the Illinois and Michigan Canal National Heritage Corridor.
0.05+	14.35+	STOP (1-way). Straight ahead across Jefferson Street is an area that was the first settled in Joliet. Several plaques have been placed on

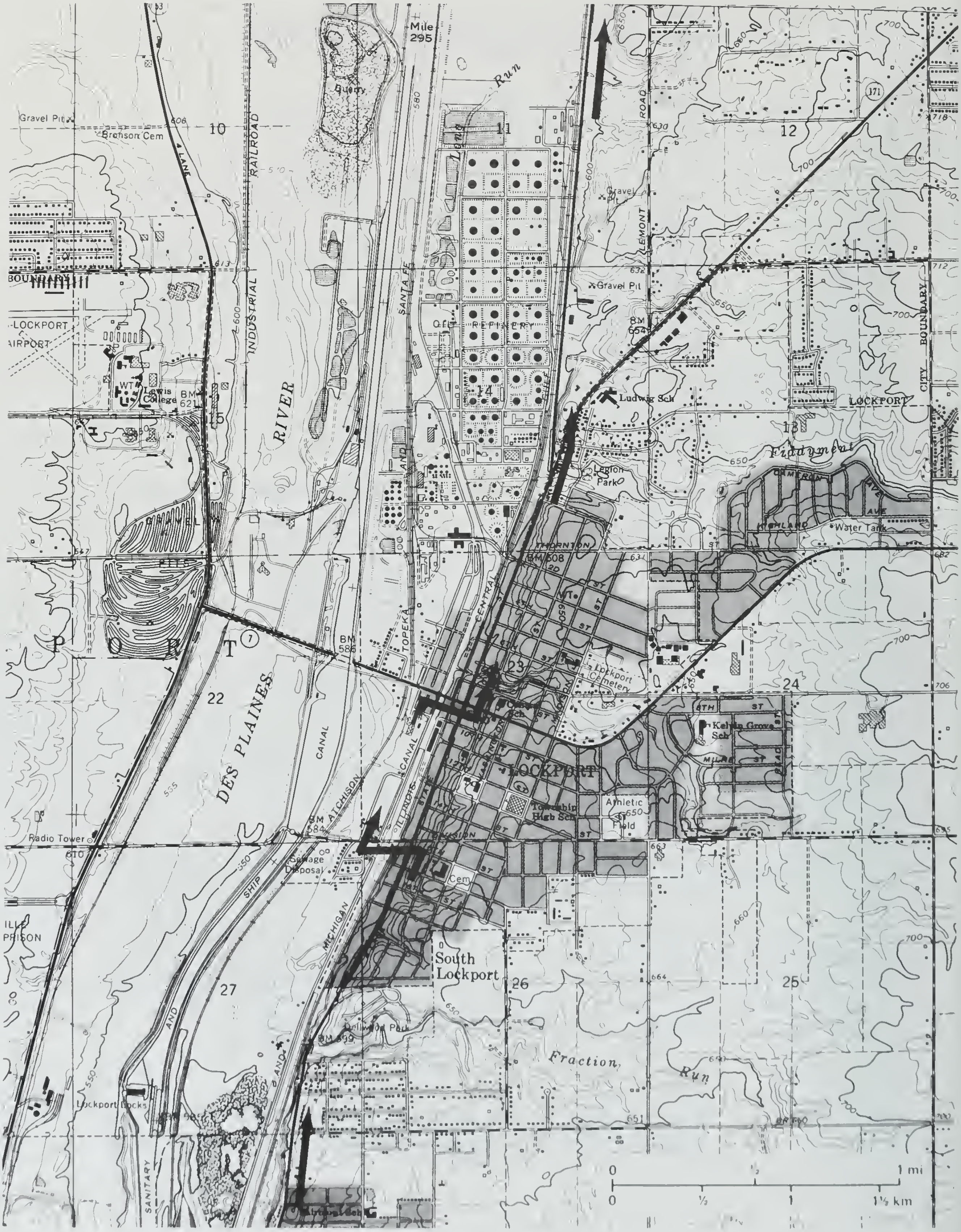

St Marys Cem
Rockdale Junction
Gravel Pit
Sewage Disposal
ELGIN
JOLIET
SANITARY
CHICAGO
St Anne Sch
Mile 290
Rivals Park
Rayner Park
St Joseph Park
St Joseph Cem
Rayner Park Sch
Mt Mount Cem
Quarry
STATE PRISON
EASTERN
Water Tanks
Hill Sch
Forest Park
WILLIAMSON
AVE
Gravel Pit
Cunningham Sch
St Johns Cem
Holy Cross Sch
CHASE
COLUMBIA
St Thaddeus Sch
OHIO
Parks Sch
JACKSON
COLLINS
College of St Francis
GLENWOOD
WESTERN
Water Tank
JOLIET
RIVER
Hospital
Shopping Center
CASS
HENDERSON
MT OLIV
Pershing Sch
ONEIDA
4 LANE
654 WEST JEFFERSON
Courthouse
Joliet Jr College
WASHINGTON
BM 558
MARION
St Patrick Sch
MIDLAND
MORGAN
Woodland Sch
Gaging Station
Reedswood Sch
Washington Sch
Hickory
Michigan Beach
Kelly Sch
DES PLAINES
Quarries
Rockdale
Mile 286
McKinley Park Sch
Sewage Disposal
Thompson Sch
0 ½ 1 mi
0 ½ 1 1½ km

boulders to mark the location of various businesses. This area is the site of the Will County Bicentennial Theater, the brick structure in the background near the canal.

TURN RIGHT (east) on Jefferson Street/US-30 and cross the Des Plaines River/Chicago Sanitary and Ship Canal/Illinois-Michigan Canal.

0.05+	14.4+	Cross the Des Plaines river.
0.2	14.6+	Stoplight. CONTINUE AHEAD.
0.05+	14.7+	Stoplight: Chicago Street. CONTINUE AHEAD.
0.05+	14.75+	Stoplight: Scott Street. CONTINUE AHEAD.
0.2+	15.0+	Stoplight: Eastern Avenue. Joliet High School administrative offices are located in the stone building to the left. CONTINUE AHEAD.
0.05+	15.05+	Stoplight: Herkimer Street. CONTINUE AHEAD on US-30 onto US-6 and CURVE LEFT.
0.2	15.25+	Stoplight. CONTINUE AHEAD (north) on Collins Street.
0.1	15.35+	Stoplight: Cass Street and junction with US-30. CONTINUE AHEAD (north) on Collins Street and US-6.
0.25+	15.6+	Stoplight: Jackson Street and junction with US-6. CONTINUE AHEAD (north); begin SR-171.
0.1+	15.75+	Stoplight: Ohio Street. CONTINUE AHEAD.
0.2	15.95+	Stoplight: Columbia Street. CONTINUE AHEAD.
0.15+	16.1+	CAUTION: guarded single track EJ&E RR crossing. Ahead you will see several buildings constructed of the "Joliet Marble" that was quarried locally.
0.45+	16.55+	Stoplight: Woodruff Road. The old state penitentiary is to the left. To the right beyond the shorter wall is the old penitentiary quarry.
0.4	16.95+	EJ&E RR overpass. As you proceed north-northeast up the hill, you will notice several abandoned quarries near the road. They are overgrown with trees and brush and frequently contain much trash. Some of these old quarries have been partially filled in and the areas turned into business sites. (Many sites that were formerly used for field trips stops are no longer available).
0.9+	17.9	View to left of the valley. The large structure at about 10 o'clock is the present Illinois State Penitentiary.

0.55+	18.45+	CAUTION: enter Lockport. Dellwood Park on the right affords a good opportunity to see some of the Silurian Niagaran Dolomite in the lower part of the valley of Fraction Run.
0.75+	19.2+	Stoplight: Division Street. TURN LEFT (west) down the hill.
0.05	19.3	CAUTION: two guarded SP/METRA RTA/AMTRAK tracks.
0.05+	19.35+	Cross I&M Canal and TURN RIGHT (north) alongside the canal. A set of canal locks is located just north of the turn. If you are interested in canal locks, you might want to come back to examine the stonework here and the restorative measures taken to protect the locks. Different types of stonework were used at various sites along the canal. If you do return, you probably should park about 0.15 mile north of Division Street and walk back to the locks. Lockport maintains a parkway along both sides of the canal.
0.55	19.9	STOP: (2-way). TURN RIGHT (east) on East 9th Street and cross the I&M Canal again. The Gaylord Building, home of canal operations, is located about one block north on the east side of the canal.
0.05	19.95	CAUTION: cross the two guarded SP/METRA RTA/AMTRAK tracks.
0.05-	19.95+	Stoplight: State Street/SR-171. TURN LEFT (north).
0.05+	20.05+	To the left is the Will County Historical Society and the location of the I&M Canal Museum. The Gaylord Building is down the hill beyond the railroad tracks on the north side of the street; the Illinois State Museum maintains a gallery in the upper floors.
0.45+	20.5+	Stoplight: Second Street. CONTINUE AHEAD (north-northeast) and MOVE TO THE INSIDE LANE.
0.2	20.7+	Prepare to leave SR-171 and turn left onto New Avenue.
0.1+	20.85	TURN LEFT (north) on New Avenue.
0.1+	20.95+	Abandoned Texaco Oil Refinery is located on the left. You can see several abandoned sand pits east of the road for some distance.
0.45+	21.4+	CAUTION: guarded railroad siding.
0.5	21.9+	The area to the right is being reclaimed, possibly for commercial use.
1.65+	23.6	Stoplight: 135th Street. CONTINUE AHEAD (north).
0.15	23.75	UNOCAL Refinery is located to left.
1.1	24.85	The Chicago Plant of the Seneca Oil Corporation, the Chemical Division of UNOCAL, is located to the left. CAUTION: rough road.


Mile
295
Quarry
Run
Long
Gravel Pit
Bronson Cem
4 LANE
RAILROAD
INDUSTRIAL
10
11
12
171
ROAD
LEMONT
Gravel
Gravel Pit
BOUNDARY
LOCKPORT
AIRPORT
SANTA FE
OIL REFINERY
BM
654
14
Ludwig Sch
LOCKPORT
CITY BOUNDARY
WTR
Lewis
College
BM
621
15
RIVER
13
Fiddyment
Legion
Park
CAMERON
AVE
HIGHLAND
AVE
Water Tank
GRAVEL
PITS
THORNTON
ST
BM 608
AND
TOPEKA
CENTRAL
P O R T
7
BM
585
23
Lockport
Cemetery
24
22
DES PLAINES
CANAL
4TH
ST
Kelvin Grove
Sch
LOCKPORT
Township
High Sch
Athletic
Field
ATCHISON
BM
584
CANAL
ILLINOIS
Radio Tower
DIVISION
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Sewage
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SHIP
PRISON
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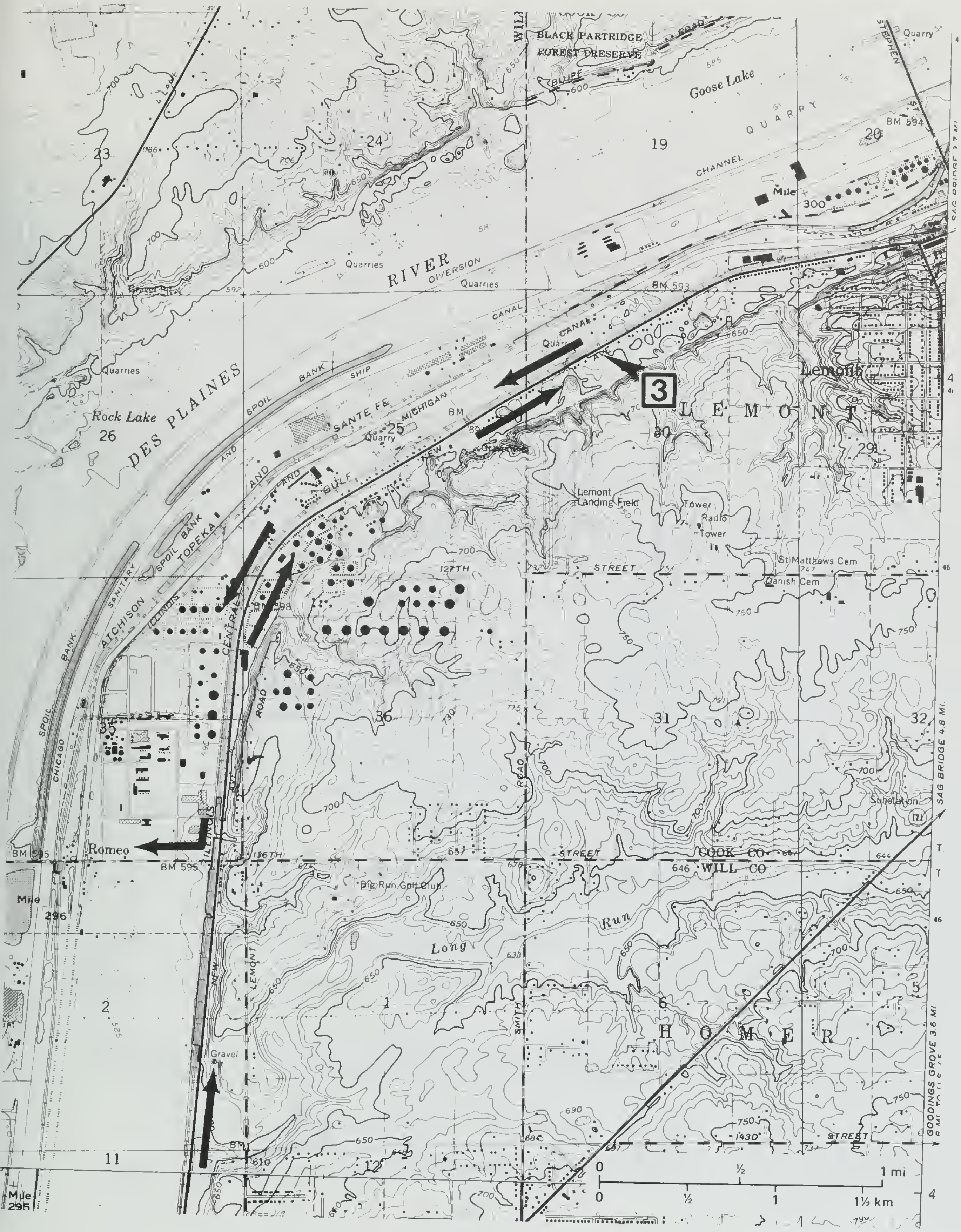
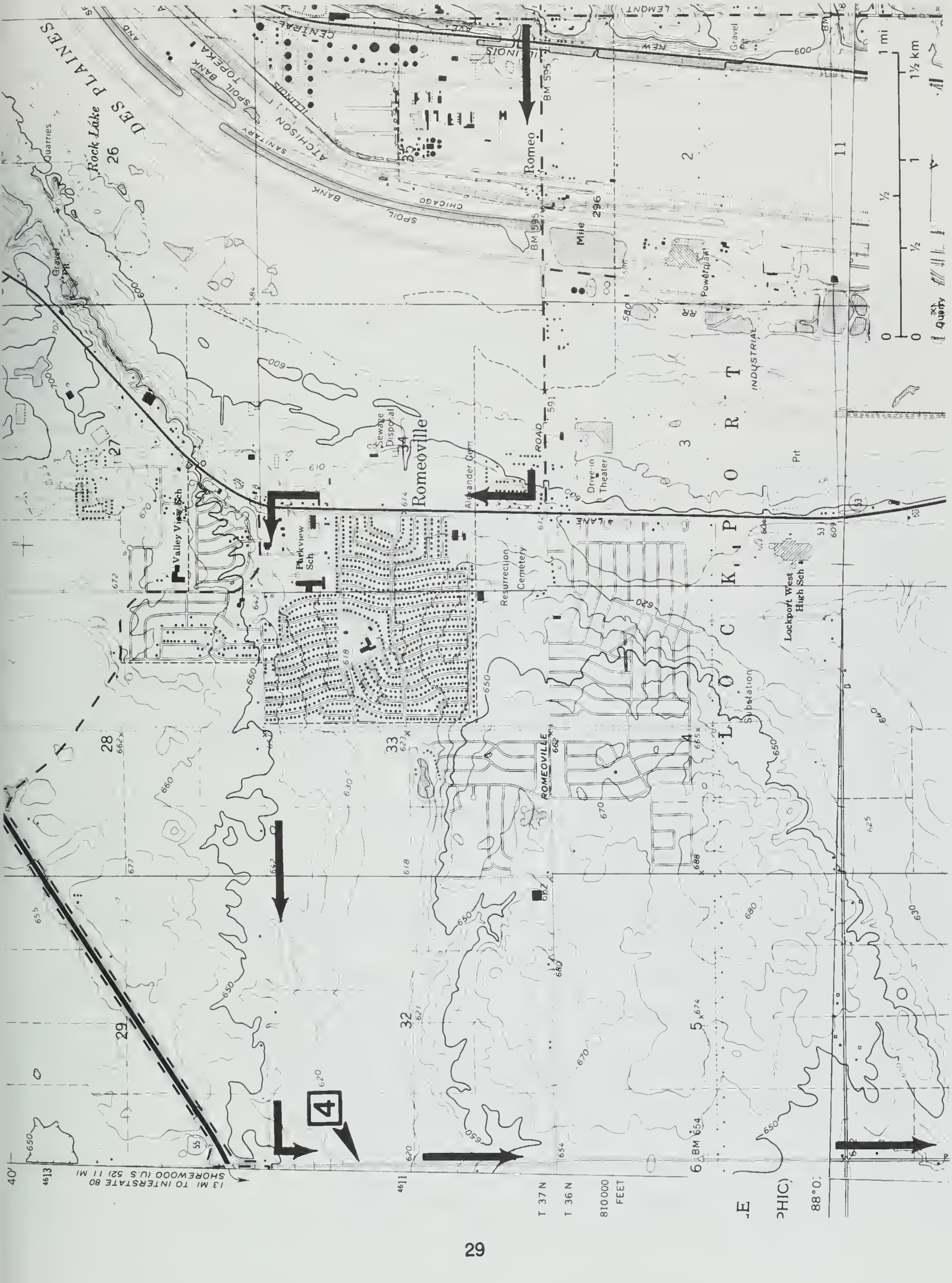

BLACK PARTRIDGE
FOREST PRESERVE
Goose Lake
QUARRY
CHANNEL
DES PLAINES
RIVER
DIVERSION
Quarries
SANITARY AND SHIP CANAL
SPOIL BANK
ATCHISON TOPEKA AND SANTE FE
ILLINOIS MICHIGAN
GULF AND
NEW
ILLINOIS CENTRAL
Rock Lake
3
Lemont
L E M O N T
Lemont Landing Field
Radio Tower
St Matthews Cem
Danish Cem
127TH STREET
135TH STREET
Romeo
COOK CO
WILL CO
Big Run Golf Club
Long Run
H O M E R
LEMONT ROAD
SMITH ROAD
Substation
Gravel Pit
Mile 300
Mile 296
Mile 295
SAG BRIDGE 4.8 MI.
GOODINGS GROVE 3.6 MI.
0 ½ 1 mi
0 ½ 1 1½ km

0.9+	25.75+	Enter Cook County.
0.15+	25.9	Prepare to turn left.
0.1+	26.05+	TURN LEFT (northwest) and cross two guarded SP/METRA RTA/AMTRAK tracks to get to the entrance gate of the Castle Flagstone Company. CAUTION: DO NOT PARK OR PAUSE on the railroad tracks. You must have permission to enter this quarry. Follow directions for parking. DO NOT CLIMB on the quarry walls and be careful where you walk.

STOP 3. We will collect fossils from the Silurian Sugar Run Formation (SW NE NW, Sec. 30, T37N, R11E, 3rd P.M., Cook County, Romeoville 7.5-minute Quadrangle [41088F1]).

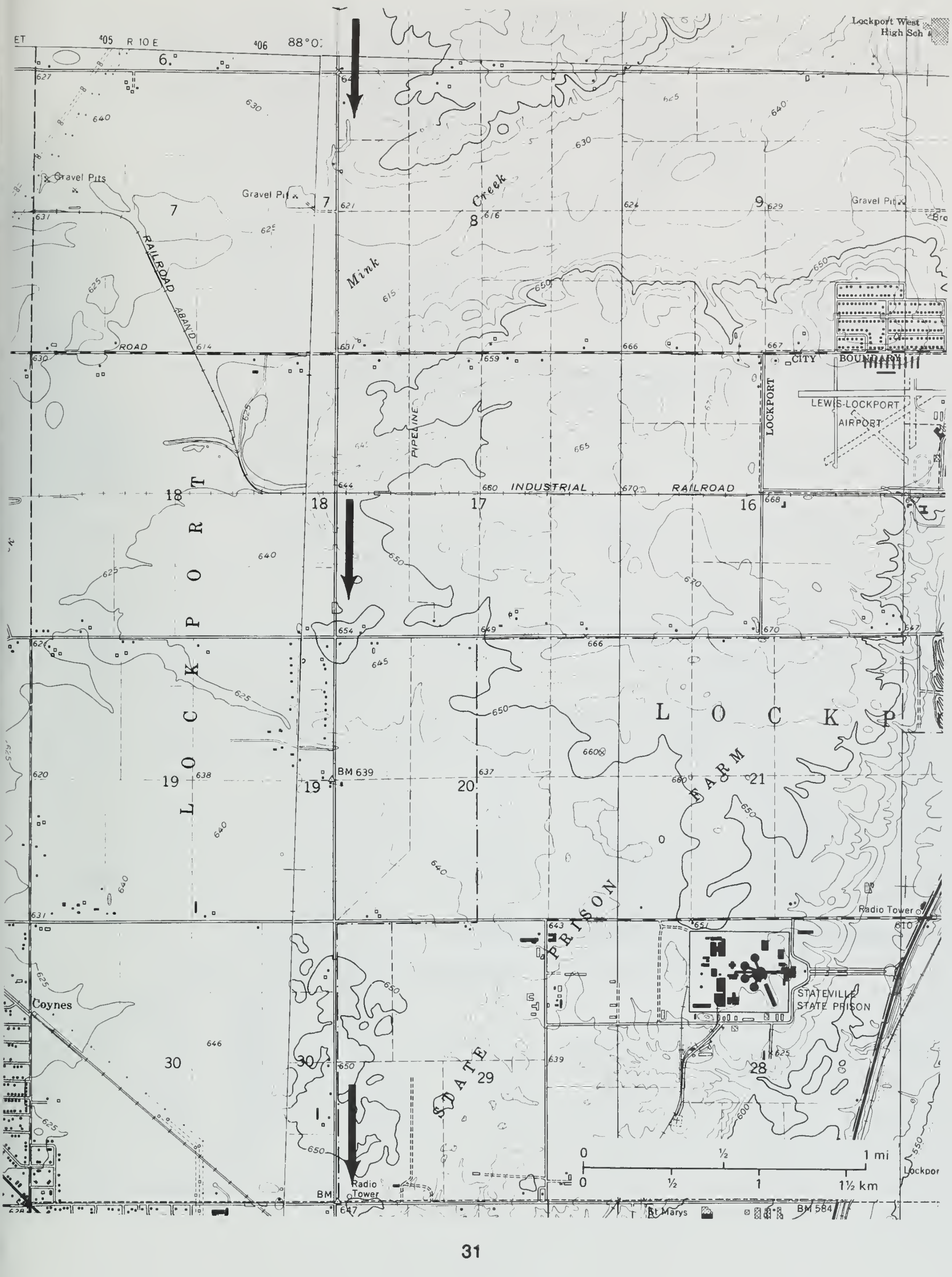
0.0	26.05+	Leave Stop 3 and retrace route southwestward to 135th Street.
0.25+	26.35+	Enter Will County again. To the left is a large abandoned sand and gravel operation; some high banks are visible in the distance.
2.15+	28.5+	Stoplight: 135th Street. TURN RIGHT (west) and immediately cross the two guarded SP tracks. You are entering Romeoville.
0.45+	29.0+	Cross I&M Canal and prepare to turn left.
0.05+	29.05+	TURN LEFT SHARPLY (south).
0.05-	29.1+	CAUTION: TURN RIGHT SHARPLY and cross two guarded Atchison, Topeka and Santa Fe (AT&SF) Railroad tracks.
0.05-	29.15	TURN RIGHT SHARPLY again onto the bridge approach.
0.05-	29.15+	CAUTION: TURN LEFT SHARPLY onto the narrow bridge across the Chicago Sanitary and Ship Canal.
0.1+	29.3	The large coal pile to the left fuels the Will County Station of Commonwealth Edison Power Generation Company.
0.2	29.5	Cross the Des Plaines River and three islands in the next 0.3+ miles.
0.75	30.25	Stoplight: crossroad. TURN RIGHT (north) on Independence Boulevard and SR-53.
0.5	30.75	Stoplight: Bellmont Drive. CONTINUE AHEAD (north) and MOVE TO THE INSIDE LANE. Prepare to turn left at the next stoplight.
0.5	31.25	Stoplight: Naperville/Normantown Road. TURN LEFT (west).
0.3	31.55	Stop: 3-way. CONTINUE AHEAD (west) on the Normantown Road;


DES PLAINES
Rock Lake
Quarries
Gravel Pit
Valley View Sch
Parkview Sch
Romeoville
Sewage Disposal
Alexander Cem
Resurrection Cemetery
ROMEOVILLE
Romeo
Mile 296
Drive-in Theater
Powerplant
INDUSTRIAL
LOCKPORT
Lockport West High Sch
Substation
Pit
Quarry
ILLINOIS CENTRAL
ATCHISON TOPEKA AND
CHICAGO SANITARY
SPOIL BANK
NEW AVE
LEMONT
ROAD
4 LANE
SHOREWOOD (U.S. 52) 11 MI
13 MI. TO INTERSTATE 80
T 37 N
T 36 N
810 000 FEET
88°0'
4

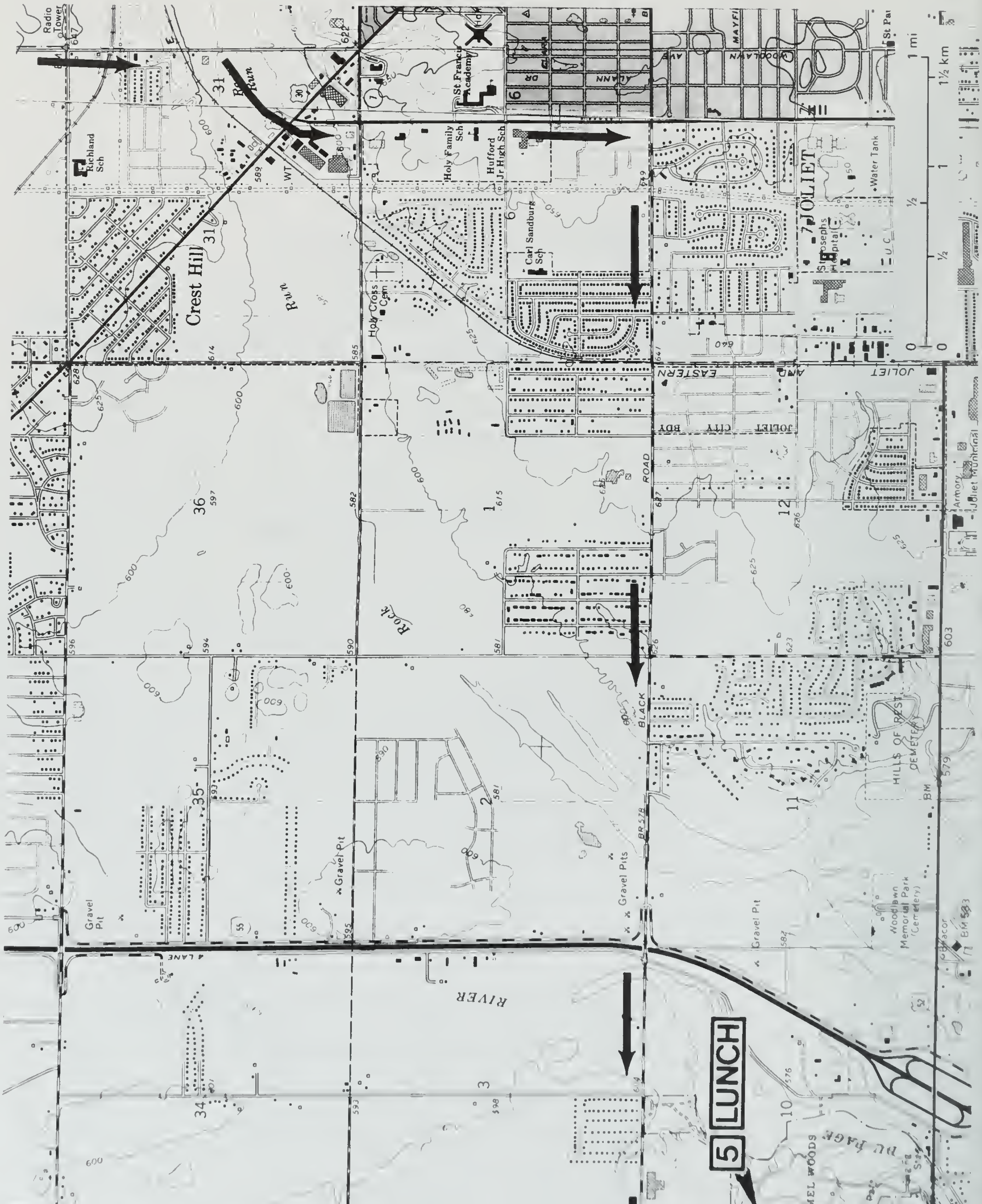
		Naperville Road turns right.
0.4+	31.95+	Stop: 3-way at Montrose Drive. CONTINUE AHEAD (west) on Normantown Road and leave Romeoville. The low area to the left is part of the Lilly-Cache glacial sluiceway.
1.6	33.55+	Stop: 1-way. TURN LEFT (south). This road becomes Larkin Avenue in Joliet.
0.3	33.85+	Park at least part-way on the road shoulder. CAUTION: get out of your vehicle on the passenger side. FAST TRAFFIC.

STOP 4. We will discuss glacial meltwater drainage through the Lilly-Cache and other channels in the area (Center E line NE SE NE, Sec. 31, T37N, R10E, 3rd P.M., Will County, Romeoville 7.5-minute Quadrangle [41088F1]).

0.0	33.85+	Leave Stop 4 and CONTINUE AHEAD (south).
2.45+	36.3+	Cross Mink Creek.
0.55	36.85+	To the left is a large landfill mound.
0.65+	37.55+	Stoplight: Renwick Road. CONTINUE AHEAD (south).
0.5	38.05	To the left at about 10 o'clock is the back side of the Stateville State Prison.
0.5	38.55	CAUTION: Division Street crossroad. CONTINUE AHEAD (south).
1.0	39.55	Caution: Caton Farm crossroad. CONTINUE AHEAD (south).
0.15	39.7	Highway overpass; EJ&E RR.
0.2+	39.9+	Caution: single guarded EJ&E RR track.
0.15+	40.1+	Cross Rock Run.
0.3	40.4+	Stoplight: Plainfield Road/US-30. CONTINUE AHEAD (south) on Larkin Avenue.
0.1+	40.55	Stoplight: mall entrance. CONTINUE AHEAD.
0.1+	40.65+	Stoplight: Theodore Street. CONTINUE AHEAD (south).
0.15+	40.8+	Stoplight: mall entrance. CONTINUE AHEAD.
0.3+	41.15+	Stoplight: Ingalls Avenue. CONTINUE AHEAD.
0.5	41.65+	Stoplight: Black Road. TURN RIGHT (west).



R 10 E
88°0
Lockport West High Sch
Gravel Pits
Gravel Pit
Mink Creek
RAILROAD ABAND
ROAD
PIPELINE
INDUSTRIAL RAILROAD
CITY BOUNDARY
LOCKPORT
LEWIS-LOCKPORT AIRPORT
LOCKPORT
LOCKP
PRISON FARM
STATE
BM 639
Radio Tower
STATEVILLE STATE PRISON
Coynes
St Marys
BM 584
Lockpor
0
½
1 mi
0
½
1
1½ km

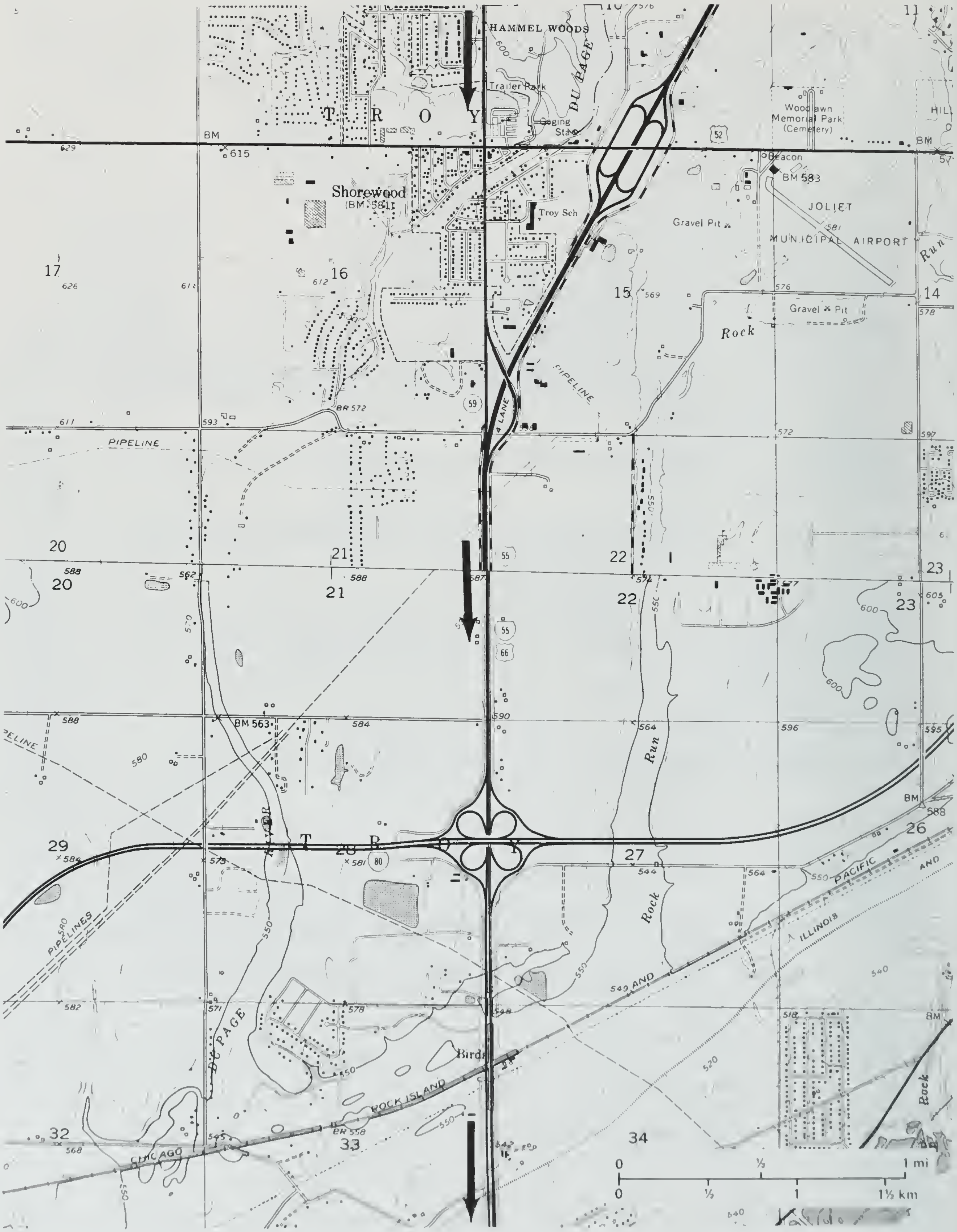


5
LUNCH
Crest Hill
JOLIET
Richland Sch
Holy Family Sch
Hufford Jr High Sch
Carl Sandburg Sch
St Francis Academy
Holy Cross Cem
St Josephs Hospital
Water Tank
Radio Tower
Gravel Pit
Gravel Pits
RIVER
BLACK
ROAD
EASTERN
DU PAGE
HILLS OF REST CEMETERY
Woodlawn Memorial Park (Cemetery)
Armory
Joliet Municipal
1 mi
1½ km

0.65	42.3+	Stoplight. To the left is Springfield Avenue; to the right is Brentwood Drive. CONTINUE AHEAD (west).
0.15+	42.5	CAUTION: single guarded EJ&E RR track.
0.5	43.0	Stoplight. CONTINUE AHEAD (west).
0.5	43.5	Stoplight: Essington Road. CONTINUE AHEAD.
0.6	44.1+	Cross Rock Run.
0.35+	44.5	Cross I-55.
0.05+	44.55+	Cross Du Page River.
0.05	44.6+	The large piles of peat on the right have been dug from marshy areas adjacent to the river. Hammel Woods, Will County Forest Preserve, lies to the left.
0.85+	45.5	Stoplight: SR-59. TURN LEFT (south) and prepare to turn left in 0.35 mile.
0.35	45.85	TURN LEFT (east) at entrance to Hammel Woods. Begin calculating your mileage again from this point.

STOP 5. Lunch in Hammel Woods (entrance: W line SW NW SW NW, Sec. 10, T35N, R9E, 3rd P.M., Will County, Plainfield 7.5-minute Quadrangle [41088E2]).

0.0	45.85	Leave Stop 5. CAUTION: TURN LEFT (south) on SR-59.
0.6	46.45+	Stoplight: Jefferson Street/US-52. CONTINUE AHEAD (south) in Shorewood.
0.1	46.55+	Cross Du Page River.
0.75	47.35	End of SR-59. CONTINUE AHEAD (south) to I-55 south.
0.15+	47.5+	CAUTION: MERGE LEFT with I-55. CONTINUE AHEAD (south).
1.1	48.6+	CAUTION as you approach I-80 interchange. CONTINUE AHEAD (south) on I-55.
0.25+	48.9+	I-80 overpass.
1.2	50.1+	Cross I&M Canal.
0.7	50.8+	Prepare to exit ahead.


HAMMEL WOODS
Trailer Park
DU PAGE
T R O Y
Woodlawn Memorial Park (Cemetery)
Shorewood
Troy Sch
Beacon
JOLIET MUNICIPAL AIRPORT
Gravel Pit
Rock
Run
PIPELINE
4 LANE
PIPELINES
T R O Y
Rock
Run
PACIFIC
AND
ILLINOIS
ROCK ISLAND
CHICAGO
DU PAGE
Birds
0
½
1 mi
0
½
1
1½ km

0.05+	50.85+	Exit I-55.
0.1+	51.0+	Stoplight: US-6. TURN RIGHT (southwest).
0.05-	51.05+	TURN RIGHT (north) on the frontage road.
0.9+	51.95+	Cross I&M Canal and prepare to turn left.
0.05-	52.0+	TURN LEFT SHARPLY (southwest).
0.25+	52.3	Entrance to Channahon Material Company: you must have permission to enter this property. Please DO NOT CLIMB on the piles of sand and gravel. Stay away from the water's edge. DO NOT THROW ROCKS. Do not mix samples from one pile with another pile.

Stop 6. Here, we will able to (1) see how sand and gravel are mined, (2) see large glacial erratics close up, (3) collect some rock and mineral specimens, and (4) possibly collect a fossil. (Entrance NE NE SW SE, Sec. 33, T35N, R9E, 3rd P.M., Will County, Channahon 7.5-minute Quadrangle [41088D2].)

0.0	52.3	Leave Stop 6 and retrace route to the northeast.
0.25+	52.55+	Stop (1-way). TURN RIGHT SHARPLY (south) on frontage road and cross I&M Canal.
0.3	52.85+	TURN RIGHT (southwest) on Canal Road.
0.85	53.7+	Abandoned gravel pit lies to the left. Topography here shows much surface sculpting by fast-flowing meltwater streams.
0.25+	54.0	I&M Canal is located to the right.
1.9+	55.9+	Stop (1-way). CONTINUE AHEAD (south).
0.2+	56.15	Stop (2-way). TURN RIGHT (southwest) on US-6.
0.15+	56.3+	Cross I&M Canal.
0.15	56.45+	Cross Du Page River.
0.6+	57.1	Prepare to turn left.
0.1	57.2	CAUTION: TURN LEFT SHARPLY (east) on Bridge Street.
0.05-	57.2+	TURN RIGHT (south) on McKinley Road. Note the gently rolling surface here on the backslope of the Minooka Moraine.

6
CHICAGO
ROCK ISLAND
LEVEE
Trailer Park
Gravel Pit
Willard Grove Cem
Pit
DU PAGE
RIVER
Channahon
C H A N N A
GRUNDY CO
WILL CO
R8E
R9E
Smith
Island
0
½
1 mi
0
½
1
1½ km

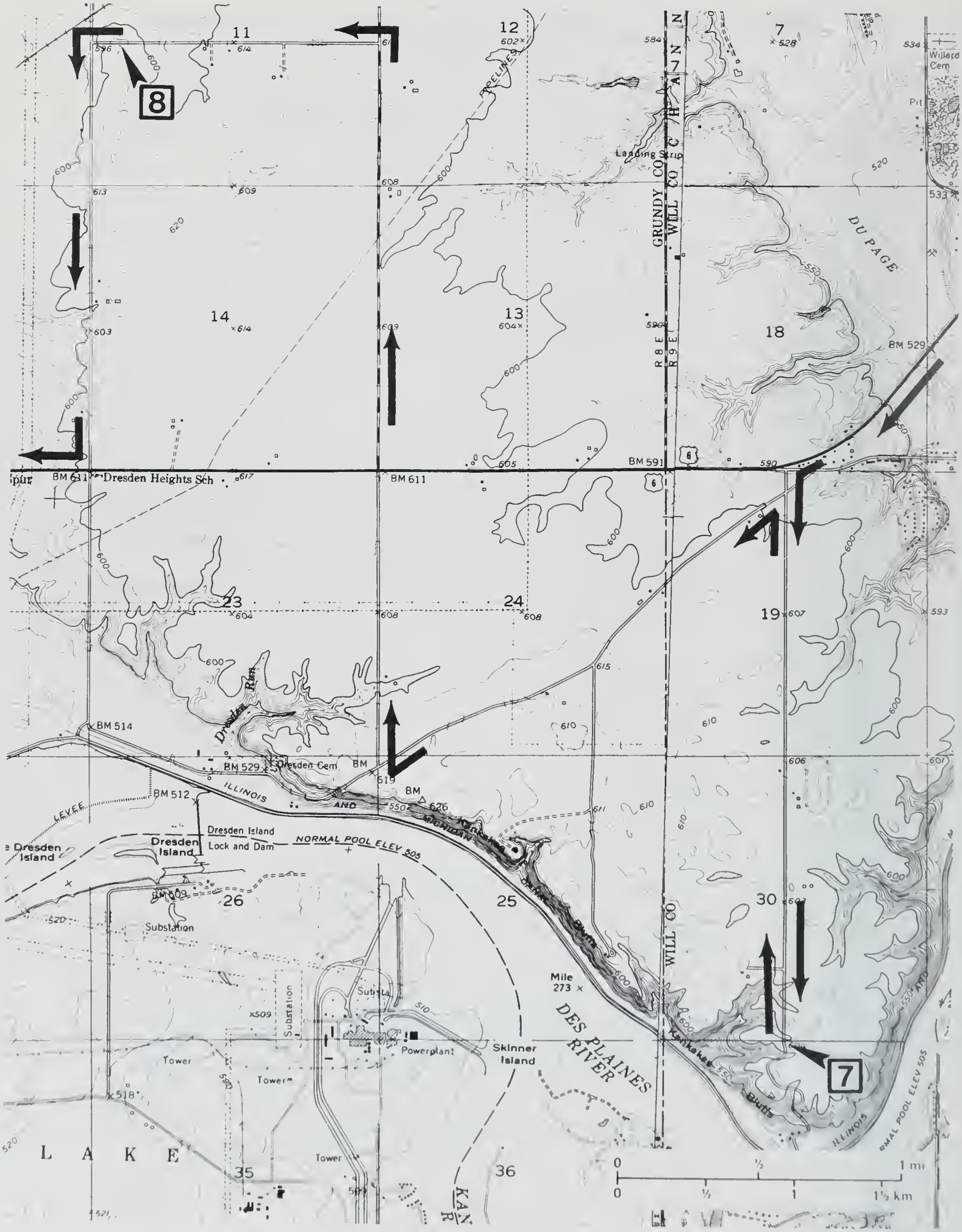
2.0	59.2+	Entrance to McKinley Woods, Will County Forest Preserve. Begin calculating your mileage again from this entrance.

STOP 7. We will view the I&M Canal and Des Plaines River and discuss the waterway (entrance: N edge NE NE NE NW, Sec. 3l, T34N, R9E, 3rd P.M., Will County, Channahon 7.5-minute Quadrangle [41088D2]).

0.0	59.2+	Leave Stop 7 and retrace the route northward across the Minooka Moraine.
1.8	61.0+	Prepare to turn left.
0.1+	61.1+	TURN LEFT SHARPLY (southwest) on Hansel Road.
0.5+	61.65+	Enter Grundy County.
1.1	62.75+	Prepare to turn right.
0.1+	62.85+	TURN RIGHT (north) on Ridge Road (8000E). The highest elevation on the Minooka Moraine, 626 feet m.s.l., is located along the "Kankakee Bluffs," about 0.2 mile southeast of this intersection. About 0.15 mile southwest of this intersection on Hansel Road, you can get a very limited view of the head (beginning) of the Illinois River and Commonwealth Edison's Dresden Nuclear Power Generation Station on the south side of the Illinois River.
0.5+	63.35+	Sags in the Minooka Moraine surface, such as the large one west of the road here, frequently hold ponds during rainy weather.
0.5	63.85+	Stop: (2-way). CROSS US-6 and CONTINUE AHEAD (north) on Ridge Road.
1.4	65.3	Prepare to turn left.
0.1	65.4	TURN LEFT (west) on Brannick Road.
0.4	65.8	Cross the crest of the Minooka Moraine.
0.5+	66.3+	Park along the roadside, as far off the road as you can safely. Watch for traffic.

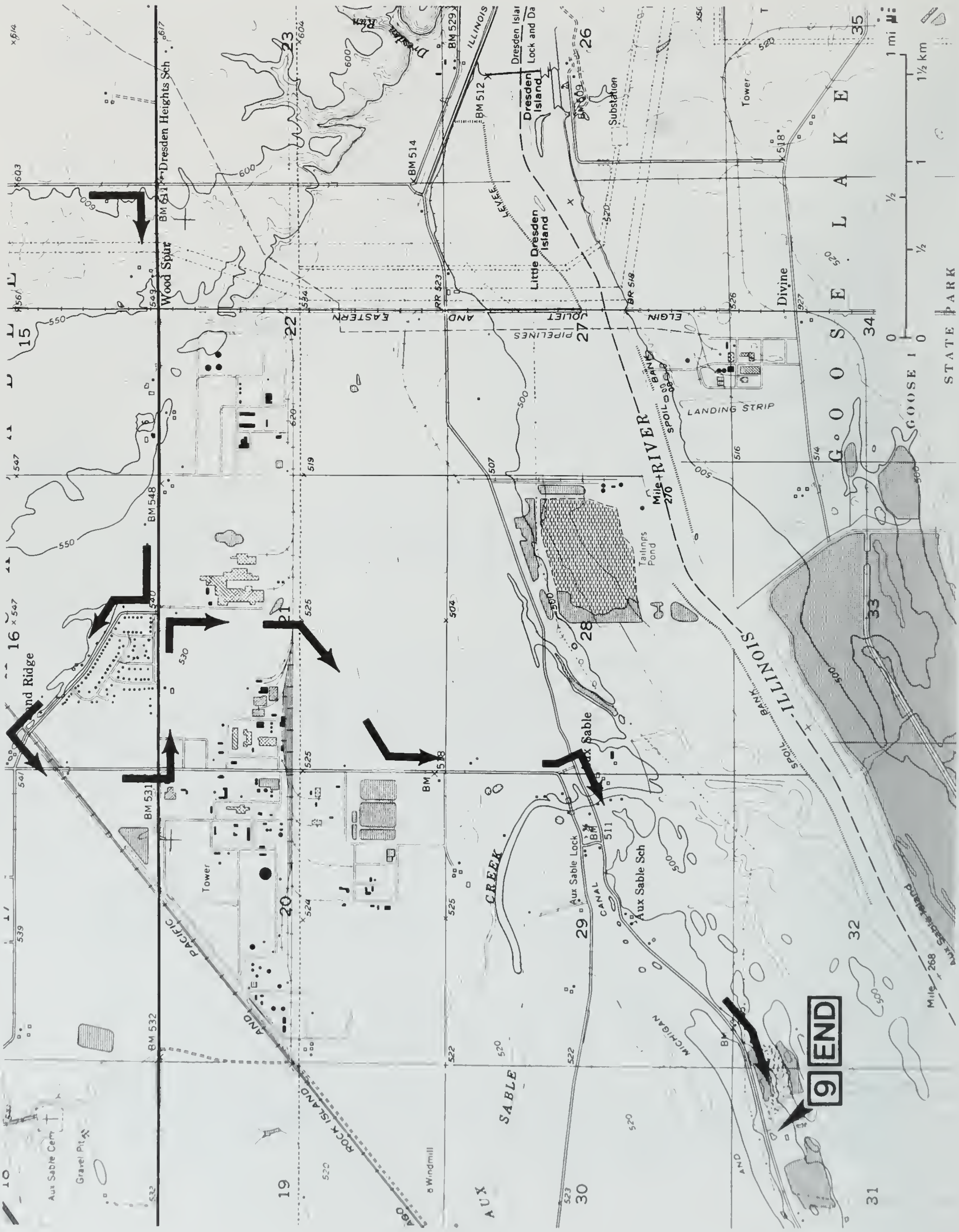
STOP 8. We will view the glacial Lake Wauponsee plain from this vantage point along the front of the Minooka Moraine (S line SE SW SW NW, Sec. 11, T34N, R8E, 3rd P.M., Grundy County, Minooka 7.5-minute Quadrangle [41088D3]).

0.0	66.3+	Leave Stop 8 and CONTINUE AHEAD (west).


8
7
11
12
13
14
18
19
23
24
25
26
30
35
36
Dresden Heights Sch
BM 611
BM 591
BM 529
BM 514
BM 512
Dresden Cem
Dresden Run
Dresden Island
Dresden Island Lock and Dam
ILLINOIS AND MICHIGAN
NORMAL POOL ELEV 505
Substation
Powerplant
Skinner Island
DES PLAINES RIVER
Kankakee Bluffs
Mile 273
GRUNDY CO
WILL CO
R 8 E
R 9 E
DU PAGE
Landing Strip
PIPELINES
Willard Cem
Pit
LEVEE
Tower
L A K E
0 ½ 1 mi
0 ½ 1 1½ km

0.05+	66.4	Stop: (1-way). TURN LEFT (south) across the rolling, leading edge of the Minooka Moraine.
1.5	67.9	Stop: (2-way). CAUTION: visibility is limited to the east. FAST TRAFFIC. TURN RIGHT (west) on US-6.
0.4+	68.3+	CAUTION: single guarded EJ&E RR track.
0.95	69.25+	Prepare to turn right.
0.1+	69.35+	TURN RIGHT (north) into community of Sand Ridge.
0.1+	69.5+	The house directly ahead is on the highest elevation (560+ feet m.s.l.) of this prominent sand dune. TURN LEFT (northwest).
0.15+	69.65+	Several driveways along the north side of the roadway have cut into and exposed the sand.
0.35+	70.0+	TURN LEFT (southwest).
0.15+	70.2+	TURN LEFT (south) on Tabler Road.
0.3+	70.5+	Stop: (2-way). The large industrial complex just ahead is the North Plant of Quantum Chemical Corporation, a USI division. CAUTION: TURN LEFT (east) on US-6.
0.35	70.85+	Prepare to turn right.
0.1+	71.0+	TURN RIGHT (south) on Tabler Road.
0.45+	71.45+	CAUTION: cross single guarded industrial railroad spur.
1.25+	72.75+	CAUTION: cross I&M Canal. View to right (west) looks down the waterway and across an aqueduct to Lock Number 8. DO NOT STOP ON THE BRIDGE.
0.05-	72.8+	CAUTION: TURN RIGHT (west).
0.1+	72.9+	Cross Aux Sable Creek. Note aqueduct to right (north) that carries the I&M Canal across the creek. The white house at about 2:30 o'clock near the canal, was the home of the lockmaster when the canal was in operation.
1.35+	74.25+	Park along the roadside. Don't get stuck. The entrance to Illinois Acres for Wildlife is in an abandoned sand and gravel pit.

STOP 9. We will discuss glacial outwash deposits (valley trains) along the Illinois River Valley (entrance: S line SW NW NE NE, Sec. 31, T34N, R8E, 3rd P.M., Grundy County, Minooka 7.5-minute Quadrangle [41088D3]).



Dresden Heights Sch
Wood Spur
Dresden Island
Little Dresden Island
Dresden Island Lock and Dam
Substation
LEVEE
ILLINOIS RIVER
Mile 270
Tailings Pond
LANDING STRIP
SPOIL BANK
Divine
Tower
GOOSE LAKE
GOOSE LAKE STATE PARK
Aux Sable
Aux Sable Lock
Aux Sable Sch
AUX SABLE CREEK
ILLINOIS AND MICHIGAN CANAL
CHICAGO ROCK ISLAND AND PACIFIC
Aux Sable Cem
Gravel Pit
Windmill
ELGIN JOLIET AND EASTERN
PIPELINES
Mile 268
9 END
1 mi
1½ km

0.0	74.25+	End of the geological science field trip through the Joliet area.

Leave Stop 9. You can retrace your route to US-6 to head toward points east and north, or you can follow this road to the southwest for about 4 miles to SR-47 at Morris.

Join us on the next field trip, September 29, 1990, at Oregon, Illinois.

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moraines,** or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

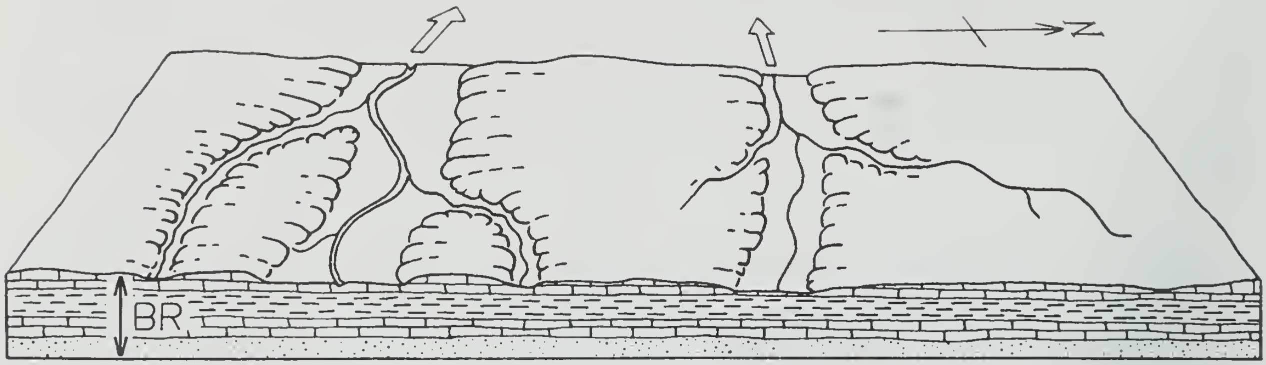
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as “key beds,” or stratigraphic markers, and are evidence of the passage of a long interval of time.

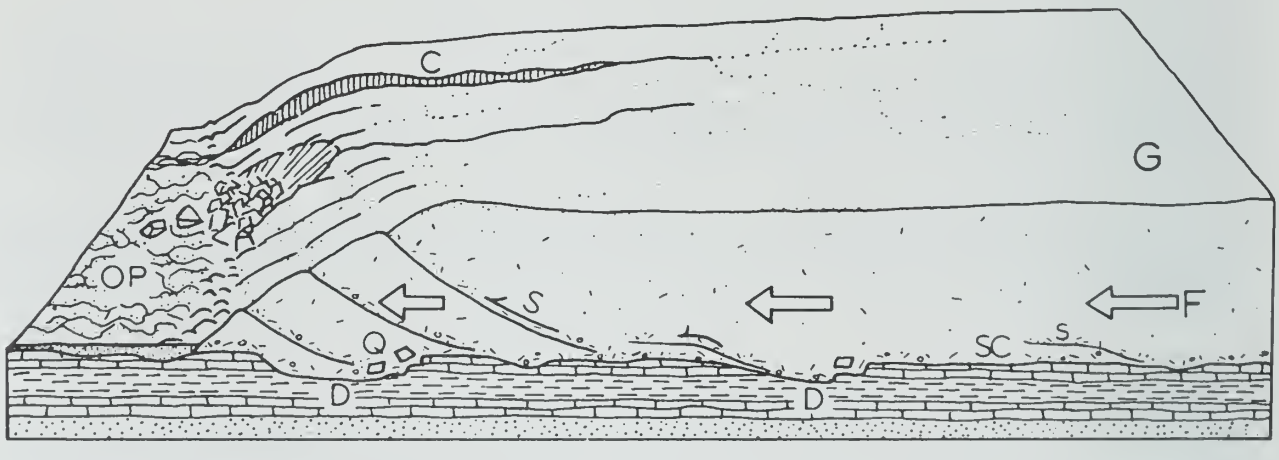
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

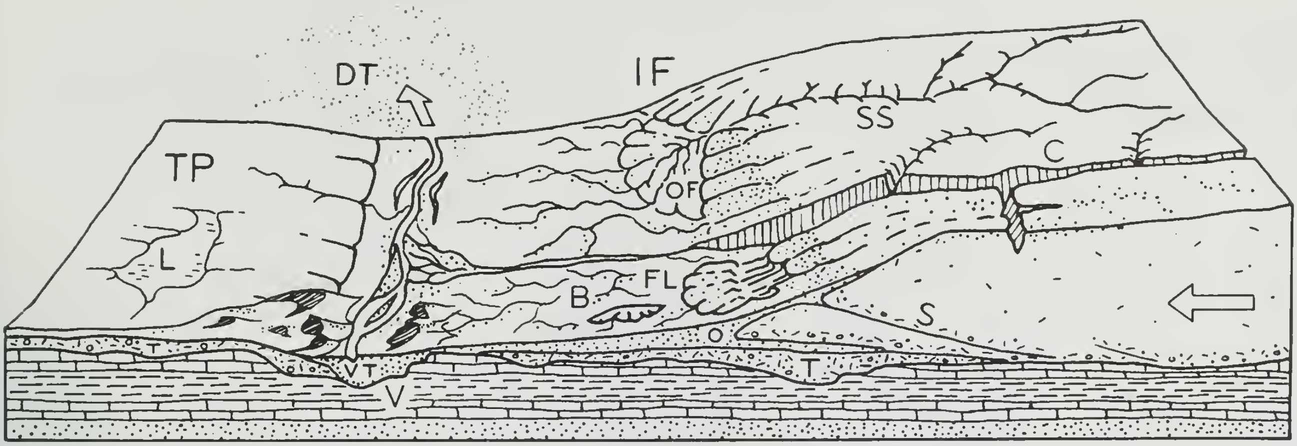
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



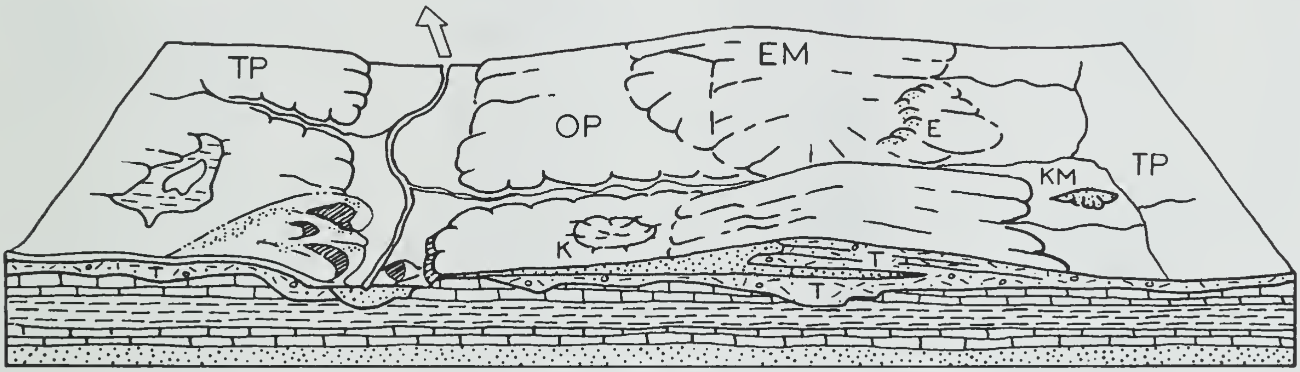
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3. **The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4. **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

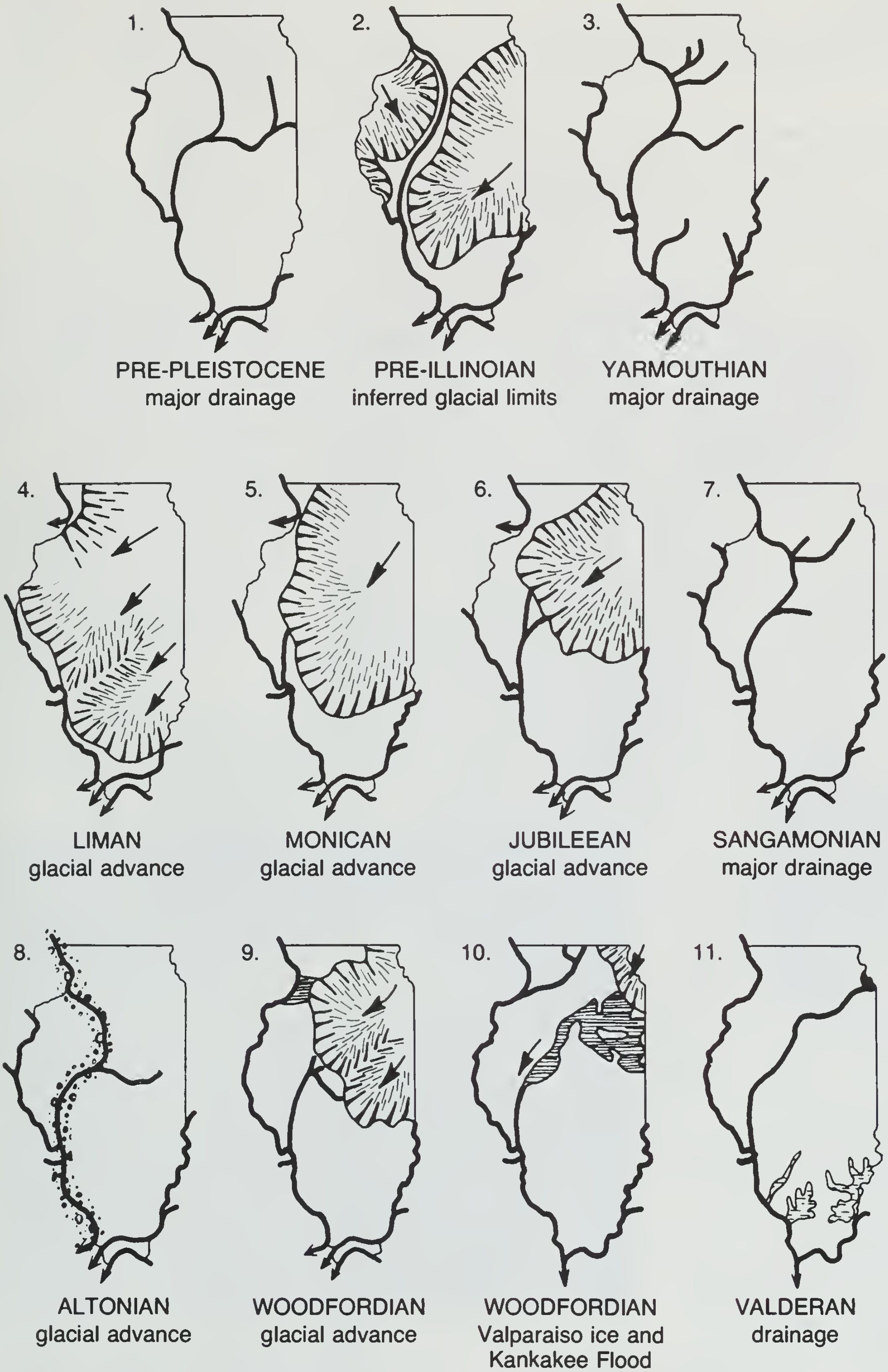
TIME TABLE OF PLEISTOCENE GLACIATION

		STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
QUATERNARY		HOLOCENE (interglacial)	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
			10,000		
	Pleistocene	WISCONSINAN (glacial)	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
			11,000		
			Twocreekan	Peat and alluvium	Ice withdrawal, erosion
			12,500		
		late	Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
			25,000		
		mid	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
			28,000		
		early	Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers
			75,000		
		SANGAMONIAN (interglacial)		Soil, mature profile of weathering	Important stratigraphic marker
			125,000		
		ILLINOIAN (glacial)	Jubileean	Drift, loess, outwash	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
			Monican	Drift, loess, outwash	
			Liman	Drift, loess, outwash	
			300,000?		
		YARMOUTHIAN (interglacial)		Soil, mature profile of weathering	Important stratigraphic marker
			500,000?		
	Pre-Illinoian	KANSAN* (glacial)		Drift, loess	Glaciers from northeast and northwest covered much of state
			700,000?		
		AFTONIAN* (interglacial)		Soil, mature profile of weathering	(hypothetical)
			900,000?		
		NEBRASKAN* (glacial)	1,600,000 or more	Drift (little known)	Glaciers from northwest invaded western Illinois

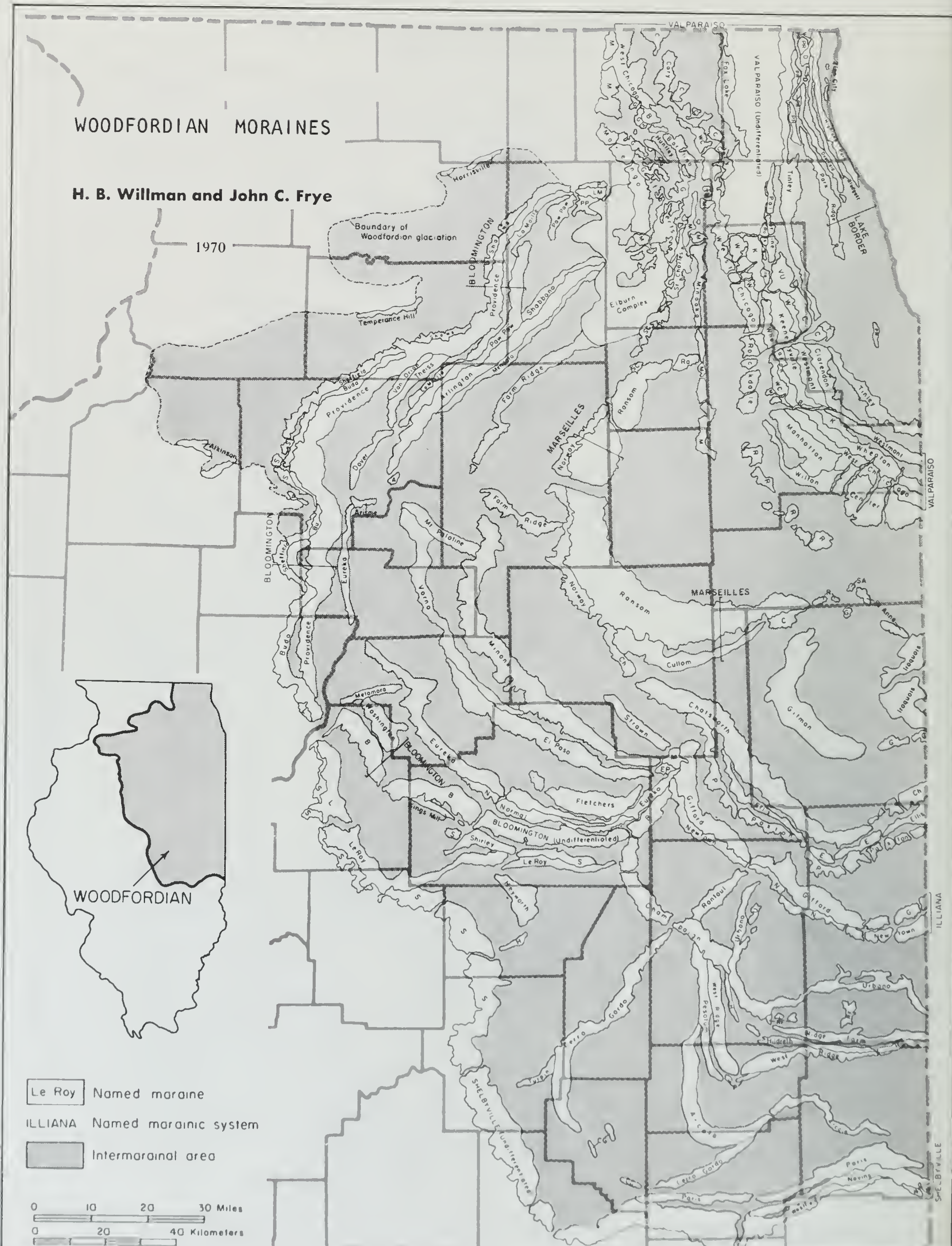
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)


WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
BLOOMINGTON
BLOOMINGTON (Undifferentiated)
MARSEILLES
ILLIANA
SHELBYVILLE
SHELBYVILLE (Undifferentiated)
Harrisville
Temperance Hill
Elburn Complex
Providence
Shabbona
Arlington
Farm Ridge
Ransom
Norway
Atkinson
Dover
Eureka
Mt Palatine
Varna
Minonk
Cullom
Chatsworth
Gilman
Iroquois
Strawn
El Paso
Fletchers
Normal
Shirley
Le Roy
Kings Mill
Metamora
Washington
Gifford
Newtown
Rantoul
Urbana
Champaign
West Ridge
Cerro Gordo
Arcola
Paris
Nevins
Tinley
Park Ridge
Manhattan
Wilton Center
Wheaton
Westmont
Keeneyville
Clarendon
Minooka
Fox Lake
Cary
West Chicago
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers

ERRATICS ARE ERRATIC

Myrna M. Killey

You may have seen them scattered here and there in Illinois—boulders, some large, some small, lying alone or with a few companions in the corner of a field, at the edge of a road, in someone's yard, or perhaps on a courthouse lawn or schoolyard. Many of them seem out of place, like rough, alien monuments in the stoneless, grassy knolls and prairies of our state. Some—the colorful and glittering granites, banded gneisses, and other intricately veined and streaked igneous and metamorphic rocks--are indeed foreign rocks, for they came from Canada and the states north of us. Others—gray and tan sedimentary rocks—are native rocks and may be no more than a few miles from their place of origin. All of these rocks are glacial boulders that were moved to their present sites by massive ice sheets that flowed across our state. If these boulders are unlike the rocks in the quarries and outcrops in the region where they are found, they are called erratics.

The continental glaciers of the Great Ice Age scoured and scraped the land surface as they advanced, pushing up chunks of bedrock and grinding them against each other or along the ground surface as the rock-laden ice sheets pushed southward. Hundreds of miles of such grinding, even on such hard rocks as granite, eventually rounded off the sharp edges of these passengers in the ice until they became the rounded, irregular boulders we see today. Although we do not know the precise manner in which erratics reached their present isolated sites, many were probably dropped directly from the melting front of a glacier. Others may have been rafted to their present resting places by icebergs on ancient lakes or on the floodwaters of some long-vanished stream as it poured from a glacier. Still others, buried in the glacial deposits, could have worked their way up to the land surface as the surrounding loose soil repeatedly froze and thawed. When the freezing ground expands, pieces of rock tend to be pushed upward, where they are more easily reached by the farmer's plow and also more likely to be exposed by erosion.

An eight-foot boulder of pink granite left by a glacier in the bed of a creek about 5 miles southwest of Alexis, Warren County, Illinois. (From ISGS Bulletin 57, 1929.)

Generally speaking, erratics found northeast of a line drawn from Freeport in Stephenson County, southward through Peoria, and then southeastward through Shelbyville to Marshall at the east edge of the state were brought in by the last glacier to enter Illinois. This glaciation, called the Wisconsinan, spread southwestward into Illinois from a center in eastern Canada, reaching our state about 75,000 years ago and (after repeated advances and retreats of the ice margin) melting from the state about 12,500 years ago. Erratics to the west or south of the great arc outlined above were brought in by a much older glacier, the Illinoian, which spread over most of the state about 300,000 to 175,000 years ago. Some erratics were brought in by even older glaciers that came from the northwest.

You may be able to locate some erratics in your neighborhood. Sometimes it is possible to tell where the rock originally came from by determining the kind of rock it is. A large boulder of granite, gneiss, or other igneous or metamorphic rock may have come from the Canadian Shield, a vast area in central and eastern Canada where rocks of Precambrian age (more than 600 million years old) are exposed at the surface. Some erratics containing flecks of copper were probably transported here from the "Copper Range" of the upper peninsula of Michigan. Large pieces of copper have been found in glacial deposits of central and northern Illinois. Light gray to white quartzite boulders with beautiful, rounded pebbles of red jasper came from a very small outcrop area near Bruce Mines, Ontario, Canada. Purplish pieces of quartzite, some of them banded, probably originated in the Baraboo Range of central Wisconsin. Most interesting of all are the few large boulders of Canadian tillite. Tillite is lithified (hardened into rock) glacial till deposited by a Precambrian glacier many millions of years older than the ones that invaded our state a mere few thousand years ago. Glacial till is an unsorted and unlayered mixture of clay, sand, gravel, and boulders that vary widely in size and shape. Tillite is a gray to greenish gray rock containing a mixture of grains of different sizes and scattered pebbles of various types and sizes.

Many erratics are of notable size and beauty, and in parts of Illinois they are commonly used in landscaping. Some are used as monuments in courthouse squares, in parks, or along highways. Many are marked with metal plaques to indicate an interesting historical spot or event. Keep an eye out for erratics. There may be some of these glacial strangers in your neighborhood that would be interesting to know.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 5
October 1975

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

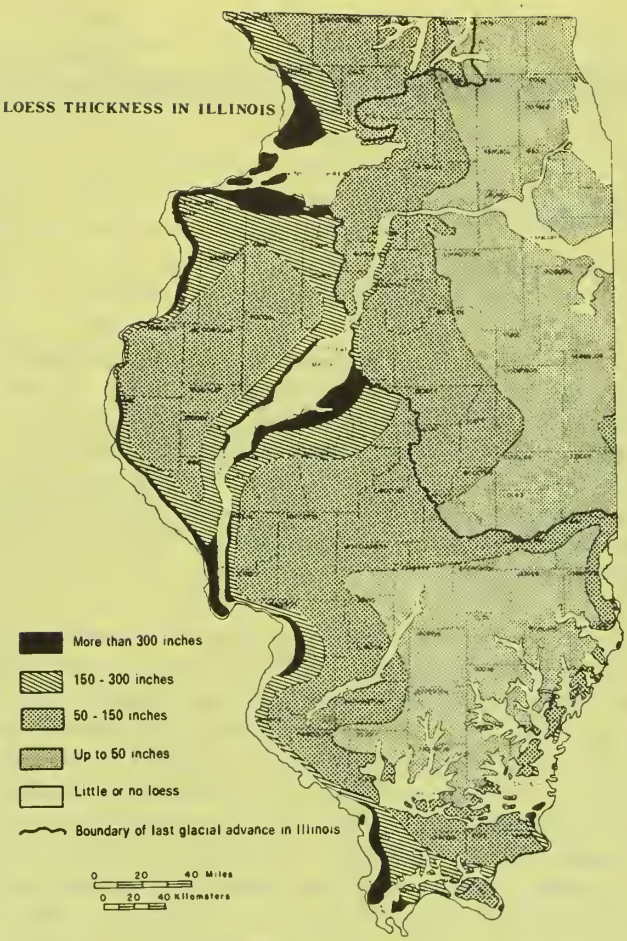
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the landscape from Canada, they moved colossal amounts of rock and earth. Much of the rock ground from the surface was kneaded into the ice and carried along, often for hundreds of miles. The glaciers acted as giant grist mills, grinding much of the rock and earth to "flour"—very fine dust-sized particles.

During the warm seasons, water from the melting ice poured from the glacier front, laden with this rock flour, called silt. In the cold months the meltwater stopped flowing and the silt was left along the channels the water had followed, where it dried out and became dust. Strong winds picked up the dust, swept it from the floodplains, and carried it to adjacent uplands. There the forests along the river valleys trapped the dust, which became part of the moist forest soil. With each storm more material accumulated until the high bluffs adjacent to major rivers were formed. The dust deposits are thicker along the eastern sides of the valleys than they are on the western sides, a fact from which geologists deduce that the prevailing winds of that time blew from west to east, the same direction as those of today. From such clues geologists conclude that the geologic processes of the past were much like those of today.

The deposits of windblown silt are called loess (rhymes with "bus"). Loess is found not only in the areas once covered by the glaciers but has been blown into the nonglaciated areas. The glaciers, therefore, influenced the present land surface well beyond the line of their farthest advance.

Loess has several interesting characteristics. Its texture is so fine and uniform that it can easily be identified in roadcuts—and because it blankets such a vast area many roads are cut through it. Even more noticeable is its tendency to stand in vertical walls. These steep walls develop as the loess drains and becomes tough, compact, and massive, much like a rock. Sometimes cracks develop in the loess, just as they do in massive limestones and sandstones. Loess makes good highway banks if it is cut vertically. A vertical cut permits maximum drainage because little surface is exposed to rain, and rainwater tends to drain straight down through it to the rock underneath. If the bank is cut at an angle more water soaks in, which causes the loess to slump down. Along Illinois roads the difference between a loess roadcut and one in ordinary glacial till is obvious. The loess has a very uniform texture, while the till is composed of a random mixture of rock debris, from clay and silt through cobbles and boulders.

Many loess deposits are worth a close look. Through a 10-power hand lens separate grains can be seen, among them many clear, glassy, quartz grains. Some loess deposits contain numerous rounded, lumpy stones called concretions. Their formation began when water percolating through the loess dissolved tiny



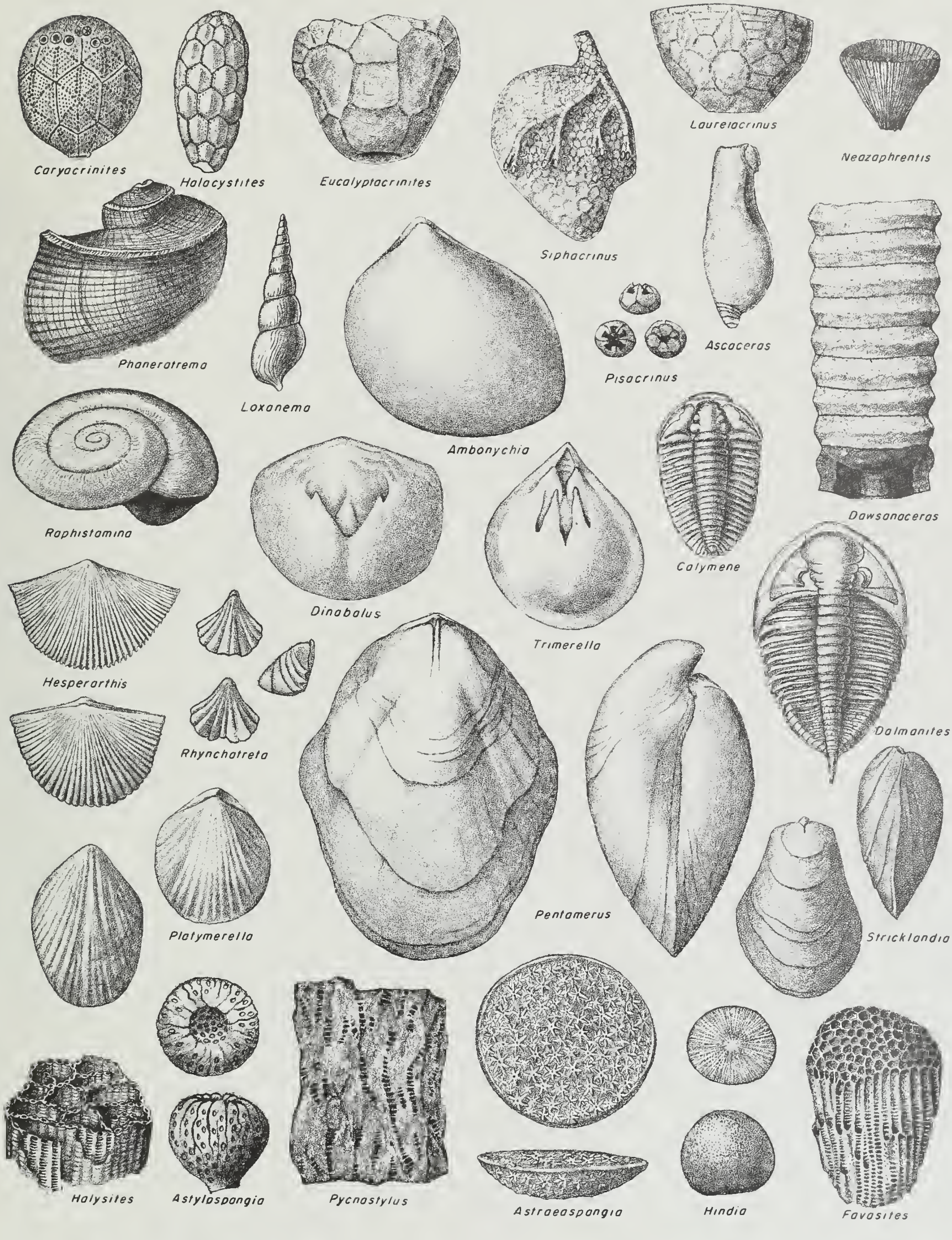
limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." They may be partly hollow and contain smaller lumps that make them rattle when shaken.

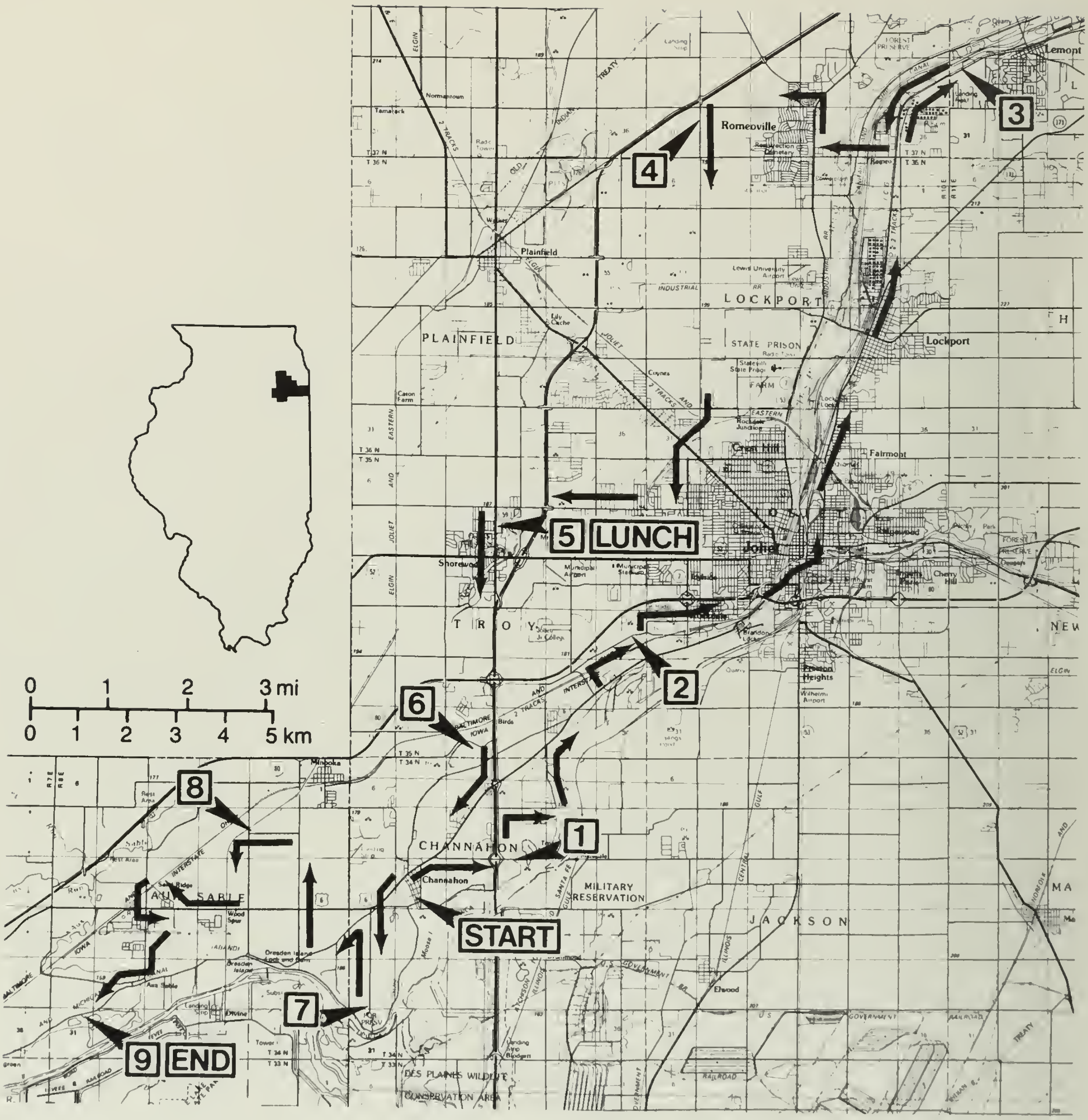
Fossil snails can be found in some loess deposits. The snails lived on the river bluffs while the loess was being deposited and were buried by the dust. When they are abundant, they are used to determine how old the loess is. The age is found by measuring the amount of radioactive carbon in the calcium carbonate of their shells.

Some of the early loess deposits were covered by new layers of loess following later glacial invasions. Many thousands of years passed between the major glacial periods, during which time the climate was as warm as that of today. During the warm intervals, the surface of the loess and other glacial deposits was exposed to weather. Soils developed on most of the terrain, altering the composition, color, and texture of the glacial material. During later advances of the ice, some of these soils were destroyed, but in many places they are preserved under the younger sediments. Such ancient buried soils can be used to determine when the materials above and below them were laid down by the ice and what changes in climate took place.

The blanket of loess deposited by the ancient dust storms forms the parent material of the rich, deep soils that today are basic to the state's agriculture. A soil made of loess crumbles easily and has great moisture-holding capacity. It also is free from rocks that might complicate cultivation. Those great dust storms that swirled over the land many thousands of years ago thus endowed Illinois with one of its greatest resources, its highly productive soil.

REPRESENTATIVE SILURIAN FOSSILS





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Plainfield
STATE PRISON
Crest Hill
Joliet
Fairmont
Shorewood
T R O Y
Minooka
CHANNAHON
Channahon
MILITARY RESERVATION
JACKSON
AU SABLE
Elwood
DES PLAINES WILDLIFE CONSERVATION AREA